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AN ECONOMIC ASSESSMENT OF CROP INSURANCE FOR SMALL FARMERS IN LATIN AMERICA

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I. INTRODUCTION AND SUMMARY OF CONCLUSIONS

Background and Objectives of the Study

Small farmers have increasingly occupied the attention of participants in the development process. It is recognized that in many developing countries small farmers, because of their predominance, are pivotal if aggregate output and income are to grow and that in most developing countries they are a focus of concern because of their low income and the increasing attention to an improved distribution of income. The attention directed to the small farmer, however, is sharply contrasted with the limited success in designing means to bring about sustained improvements in agricultural output by small farmers.

The search continues for successful program and policy instruments to encourage small farmers to increase the productivity of their agricultural enterprises and, hence, to increase their income. This study of crop insurance is a part of this search. Increased productivity and corresponding growth of income is in large measure dependent on new technologies employed by small farmers, but these new technologies contain both risk and uncertainty for the small

farmer. The uncertainty arises because the consequences are not completely understood by him, while the risk arises from his perception of a higher exposure because of increased expenditures and debt, which might cause him to fall below a minimum level of income in a bad crop year. Reducing the small farmer's burden of risk and uncertainty may induce him to adopt new technologies sooner than he would otherwise. Crop insurance is a potential instrument for reducing the small farmer's burden of risk and uncertainty, thereby leading to a more rapid increase in his productivity and income.

The principal objective of this study is to assess the economic implications and viability of crop insurance as an instrument of development policy for small farmers in Latin America. While crop insurance can serve other objectives as well, such as maintenance of income and protection against disastrous events (as fire insurance does), in this study crop insurance is evaluated solely in terms of its utility as a mechanism to encourage small farmers to adopt higher-productivity technologies. It is recognized that there are other policy tools which may also serve to reduce the small farmer's burden of risk, but the comparative evaluation of these alternatives to crop insurance has not been included in this study.

The overall objective of the study is based on several specific goals. These include: (1) the identification and analysis of variables associated with the adoption of technological change, with particular attention directed to the role of risk and uncertainty; (2) the assessment of the

economic costs and benefits of a hypothetical crop insurance program; (3) the analysis of impacts -- cropping patterns, technologies, income -- on small farms under conditions with and without insurance, (4) the analysis of the macroeconomic implications of a crop insurance program which are not reflected in the cost-benefit analysis of (2); and (5) an assessment of the institutional and operational problems which the introduction of a crop insurance program for small farmers might encounter.

Approach to the Study

This economic assessment of a crop insurance program for small farmers must be considered as a preliminary step of an ongoing research and analysis activity. Although there is a relatively abundant literature on crop insurance programs in developing countries, this literature falls into two categories: the purely descriptive and that which is concerned with the technical operational features of insurance. Thus far there has been no analytical study of crop insurance as an instrument of development policy which addresses the objectives described above. This study represents the first effort to quantify the economic implications of a crop insurance program in developing countries.

The analytical approach to this study was limited by two factors. First, the experience of developing countries with crop insurance is limited. While a variety of developing countries have introduced crop insurance in some form, these programs have tended to be restricted to limited crops for specific hazards and oriented to income maintenance or protection against disastrous events rather than as a policy instrument to induce technological change and increased

productivity. The one exception is Mexico, whose long experience with crop insurance can serve as a useful guide for other developing countries.

Second, there was no specified program proposed for a specific country to which the analysis could be directed. Rather, the economic assessment had to be directed to a generic crop insurance program, whose characteristics were specified by the study team. The cost-benefit analysis, for example, is based on an illustrative crop insurance program for a representative small Latin American country. This factor does not detract from the relevancy and conclusions of the analysis, but it does point to the need for continued economic analysis of individual crop insurance programs as they are proposed for particular countries.

The analysis of this study was focused on four central issues:

- the nature of decisionmaking and risk behavior by small farmers;
- the varying impacts on small farms under conditions with crop insurance and without insurance;
- the net economic gains (losses) to a developing country attributed to the introduction of a crop insurance program for small farmers; and
- the institutional constraints and basic operational features of such an insurance program.

In addressing these issues the study depended heavily on three analytical tools. The first was a detailed statistical analysis drawing upon farm survey data from Guatemala

(for 1973) and Colombia (1969). This statistical analysis was designed to examine the relationship between variable expenditures of farmers (in other words, those expenditures over which they have control and which can therefore serve as a proxy in part for their perception of risk) and the yield, returns, and level of technology employed. This analysis was done by crop and by region. Through this analysis we expected to refine quantitatively our insights into the behavior of farmers in terms of the level of expenditures they were prepared to incur and the returns received. It was also expected that the analysis in itself would provide useful insights concerning the feasibility of various facets of a crop insurance program.[1]

The second analytical tool, and the one which is most central to the study, was a linear programming model of small farmers in the central highlands region of Guatemala.[2] The linear programming model served two important functions in the assessment of crop insurance programs: to estimate the benefits attributed to a crop insurance program and to identify other impacts (for example, shifts in cropping patterns) which such a program may induce. The linear programming model for Guatemala was selected in part because of

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1. In the interest of broadening the geographical representation of this statistical analysis, an effort was made to repeat this analysis for a recently completed farm survey in Paraguay. Unfortunately, the computer tapes were not ready in time to be utilized in this study.

2. It should be noted that the decision to use Guatemala data, for both the statistical analysis and the linear programming model, is because of their ready availability rather than because of the predetermined interest in Guatemala as such. Throughout the report, values are expressed in quetzales unless otherwise specified, with 1 quetzal (Q) equal to 1 U.S. dollar.

its ready availability, but a more important reason was to have an analytical tool for estimating benefits which permits decisionmaking by farmers to incorporate simultaneously the choice of technology, the risk, and the influence of crop insurance. Although there are conceptual and empirical limitations to the linear programming model, it serves as a highly useful analytical tool for simulating quantitatively the impacts of a crop insurance program under a wide range of assumptions and varying values for key parameters.[1]

The third analytical tool for the study is a cost-benefit analysis. The cost-benefit analysis is intended to provide an overall measure of the net economic gains (losses) to a developing country with the introduction of a crop insurance program. The benefits for the cost-benefit model were derived from the linear programming model while the cost data were estimated independently.

These basic analytical tools were supplemented by other activities and inputs. One was a review of the literature on risk and uncertainty (particularly as it relates to decisionmaking by small farmers) and the experience of crop insurance programs in developing countries. A seminar sponsored by AID involving three noted anthropologists provided useful insights into the behavior of small farmers and their response to crop insurance. In addition, the study team benefited from the information and observations from the field visits of the AID project monitors.

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1. Computer programming assistance and use of computer facilities were provided by AID for both the statistical analysis and the linear programming model.

Conclusions and Recommendations

General Conclusions

An overall conclusion which emerges from this study is that crop insurance for small farmers offers the potential of being a useful instrument for increasing agricultural production in developing countries and for improving the welfare of small farmers. The concept of crop insurance as a means of encouraging small farmers to adopt higher-productivity technologies merits serious consideration, including the commitment of resources for a trial of such a program. One prospective approach for such a trial is outlined briefly below.

The potentiality of crop insurance must be stressed, and for several reasons. First, experience with crop insurance in developing countries is varied, but there is limited experience with, and hence knowledge about, crop insurance programs designed for small farmers and intended to increase agricultural productivity. Second, this study did not have the benefit of assessment of an actual proposed program for a specified country and thus had to rely on the specification of an illustrative program. Third, in certain circumstances emphasis on alternative agricultural programs and policies may be able to achieve the same objective more effectively than crop insurance, but a comparative analysis could not be undertaken within the framework and resources of this study. Finally, the potentiality of crop insurance for small farmers rests heavily on overcoming a variety of institutional constraints.

Conclusions of the Economic Analysis

The cost-benefit analysis of the illustrative crop insurance program -- modest in size and rate of growth -- yielded high net benefits. The internal rate of return ranges from about 50 percent to about 185 percent, depending on the particular cost and benefit values employed. These represent a high level of national economic profitability by any standard. The results of the economic analysis also demonstrate that the income of small farmers can be increased substantially with crop insurance. There are, however, several cautionary notes which must be recognized: the cost-benefit analysis was based on an illustrative program; some of the increase in agricultural productivity (that is, program benefits) is a function of other activities, such as credit and extension services, which cannot readily be isolated; it was assumed that the crop insurance program, albeit modest in size, was a well-functioning program, with farmers understanding the program and hence willing to participate; and the accumulated knowledge on selected variables, particularly small farmers' perception of risk, is admittedly limited.

There are other economic impacts of a crop insurance program which are not reflected in the cost-benefit analysis. Because of the modest scale of the illustrative program, these impacts tend to be small in absolute terms but are generally positive. In particular, crop insurance programs for small farmers should generate additional employment, increase the availability of foreign exchange, improve the distribution of income, increase savings, and reduce the risk of decapitalization of credit institutions. On the other hand, a crop insurance program which concentrates

on only one or a few crops -- as suggested below for the initial development -- may lead to a distortion in the allocation of resources, just as would be the case with, say, an artifically high price-support program.

Conclusions on Institutional Considerations

The economic analysis clearly suggests that crop insurance for small farmers is a promising agricultural development mechanism. Yet there are institutional considerations which temper this conclusion. The introduction of crop insurance will confront a number of constraints: existing agricultural services, on which crop insurance is dependent, reach only a nominal share of the universe of small farmers in most developing countries; the crop yield data for determining a sound actuarial base are sparse; there are existing traditional systems for managing risk which may deter the introduction of crop insurance (and should not be lost through a poorly implemented crop insurance program); understanding of crop insurance will not come easily to small farmers, in part because of an expected initial uncertainty on their part as to who benefits from it; and the characteristics of landholdings of small farmers -- often very small and fragmented -- will lead to demanding requirements for supervision and high administrative costs.

The basic operational features of a crop insurance program should reflect these constraints. A program of modest scale seems essential, with a limited number of participants and only selected crops being covered in the initial years. An appropriate design period is equally

essential, concentrating on development of crop yield data (cross-section data for selected years may offer a reasonable substitute for time-series data), implementation of pilot programs to learn and train staff and the preparation of an educational component which can communicate the features of insurance to small farmers. Well-designed communication is the critical link for bridging the expected improvement in the income of small farmers resulting from crop insurance (as indicated by the results of the economic analysis) and the institutional factors which may impede the initial response by farmers to insurance. The crop insurance program should be linked closely, if not formally, with existing agricultural services reaching small farmers, which means that the size and growth of the insurance program are determined by these services.

There are numerous factors affecting the premium and indemnity features of a crop insurance program. These are discussed in Chapter IV and need not be reviewed here. There is, however, one important implication of premiums and indemnities which should be addressed, and that is the financial viability of a crop insurance program. There is a tendency to consider commercial, or financial, viability of a crop insurance program as an essential feature, much as with a credit institution. This need not be the case. As long as the national economic benefits of an insurance program are positive, the financial viability of institution operating the program is of secondary importance. Indeed, the structure of premiums and indemnities should be guided principally by the objectives of the program (increased productivity through adoption of higher technologies) and the target group (small farmers), rather than by the financial soundness of the managing institution.

Recommendations for Follow-on Activities

One observation which emerged through the course of this study is that the knowledge base for crop insurance programs for small farmers is a very limited one. This is due in large part to the limited experience of such programs, and in part to poor understanding of small farmer behavior in the management of risk and adoption of technology. The three recommended follow-on activities described briefly below are all directed to improving the knowledge base for crop insurance programs targeted to small farmers.

For reasons discussed in Chapter II, small farmers' perception of risk and its impact on their decisions is a subject which remains clouded. Improved understanding of this variable has a direct bearing on the design of crop insurance programs, but achieving a better understanding is difficult given the very nature of the variable. One possible albeit modest research task which might be undertaken is to expand for Guatemala and Colombia the statistical analysis initiated in this study. First, the same analysis could be repeated for other countries where farm-survey data permit (Paraguay and the Dominican Republic are two immediate candidates), principally to determine whether similar patterns emerge. Second, alternative statistical analyses for the same countries could be considered to see whether factors affecting the management of small farmers' risks could be determined with greater precision than was possible within the time and resources of this study. A better understanding of small farmers' risk function would also emerge as one output of another proposed research activity discussed below.

A second follow-on activity recommended for consideration is a thorough analysis of the Mexican crop insurance program. Mexico offers the only example of an apparently successful all-risk crop insurance program in a developing country. While there are several descriptions of the program and analyses of selected components (such as in the context of Plan Puebla), there has not been a systematic and quantitative analysis of its economic and social impact. Although this analysis would be complicated by Mexico's compulsory linking of insurance with credit, the results should be illuminating for the design of other crop insurance programs.

The third recommended activity is more ambitious and demanding of resources, and that is to establish a pilot program of crop insurance for small farmers in one Latin American country -- possibly in more than one. It would be desirable for this pilot program to have several dimensions: 2 or 3 groups of small farmers in distinctly different areas (possibly of different cultural characteristics) who would agree to participate in the program; parallel control groups of farmers who would not participate but have access to the same set of other services; and a careful monitoring of farmers' behavior and results over a period of several years. The monitoring system would have to be carefully designed, with social scientists in the concerned country having principal responsibility for the monitoring function. By having several pilot programs, either in the same country or across several countries, with control group specifically included, it would be possible to test a number of important variables. A better understanding of the small farmers' risk function should

emerge. The responsiveness of farmers to crop insurance could be tested in the context of real decisions rather than having to depend on assessing farmers' demand for insurance by postulating a hypothetical program. Alternative premium and indemnity systems could be tested. The viability of alternative delivery systems, such as with and without linkage to credit, might also be assessed. Most important would be the opportunity to measure the extent to which crop insurance changes patterns of agricultural production, adoption of new technologies, and improvement in the income of small farmers.

In addition to the substantial body of knowledge which should be generated by this pilot program, it could also serve as a means to develop expertise in the management of an insurance program and provide the basis for subsequent extension of insurance to a broader base.

II. FACTORS AFFECTING THE FEASIBILITY OF CROP INSURANCE IN DEVELOPING COUNTRIES

Experience with Crop Insurance Programs

The oldest form of standing crop insurance is that against specific risks such as hail and windstorms. Such insurance, offered by private companies, cooperatives, or state agencies has a long history in Western Europe. The record of experience with all- or multiple-risk crop production insurance goes back to the turn of the century in the United States. Private companies offered all-risk insurance at various times and places, but such attempts were generally unsuccessful and short-lived.

Research on crop insurance began in the U.S. Department of Agriculture in the 1920s, and this eventually led to the original U.S. crop insurance legislation in 1938. Interest had been stimulated by the extended drought in the Great Plains in the mid 1930s. Japan began its government-sponsored crop insurance at almost exactly the same time.

Over the past three decades, at least a dozen other countries have started crop insurance programs, and several more have taken preliminary steps in development of programs.[1]

The countries with insurance programs are widely distributed geographically, and it is not readily apparent what if anything they have in common with respect to stage of economic development or variety and quality of agricultural services provided by the public or private sectors. It is perhaps reasonable to conclude that most of these countries are at least some distance up the scale in agricultural development. This may be another way of saying that crop insurance is a service that has only been introduced after some progress has been made with other services such as research, extension, credit, and the distribution of supplies of various inputs. The dependence of crop insurance programs on the existence and quality of these other services and the stage of development at which crop insurance is initiated are questions for further consideration.

The several national programs display considerable variety. Some are compulsory while others are voluntary. Countries with one or more major crops subject to frequent

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1. The following discussion of crop insurance programs is intended to provide an overview of the experience with crop insurance and to identify factors which are expected to influence the feasibility of a crop insurance program for small farmers. There is an extensive literature on crop insurance but as noted in chapter I, the orientation of this literature is descriptive rather than analytical. A reasonably comprehensive and current summary of crop insurance programs is provided by Vincent R. McDonald, Crop and Livestock Insurance: An Aid to Small Farmer Development, International Bank for Reconstruction and Development, Rural Development Division, Working Paper No. 2, 1975.

and severe damage by hail or wind (hurricanes) may start out with insurance to cover this hazard. For example, Jamaica developed insurance against wind damage to bananas, and Mauritius against hurricane damage to sugarcane. The United States has commercial hail insurance in certain highly susceptible areas, and South Africa has hail insurance patterned after that in the United States.

Hail and damaging winds often strike suddenly and destroy or severely damage crops in a very short time. Such damage may be highly localized and can be readily observed and assessed. Drought damage, by way of contrast, develops more gradually, and a crop in precarious condition may be saved by timely rain. It is not only the annual rainfall that is important, but also its distribution in relation to critical stages in the growth of the crop. It may be difficult to ascertain just how much drought actually reduced yield below a particular benchmark. This may help to explain the greater popularity of insurance against hail and wind damage in situations where major crops are vulnerable to these hazards.

All-risk insurance is more complicated because it is necessary to compare actual yields that would have been realized with acceptable performance by the farmers. All-risk insurance is generally production insurance and does not cover price declines. There may be other measures to support or stabilize prices as well as debt payment moratoria or other forms of relief from severely depressed prices.

There are few examples of successful all-risk crop insurance programs in developing countries. Most tend to concentrate on one or two crops (such as rice in Costa Rica and Sri Lanka) and have had faltering experience with farmer participation and the financing of the program. Brazil dissolved its crop insurance program in 1967 after 13 years. Management deficiencies and poor planning of the insurance program are often the principal explanations for poor performance with more comprehensive programs.

Mexico is one developing country which has managed to establish a large and ongoing all-risk insurance program for a wide variety of crops in all regions. Established in 1961, the government-sponsored program now covers almost 1 million farmers. With insurance participants having an average holding of 3.5 hectares, the program has managed to reach small farmers. Mexico's program is compulsory, in the sense that any farmer who receives supervised credit must have crop insurance. The insurance coverage is limited to the amount of the credit, which as noted later may restrict the farmers' willingness to purchase crop insurance on a voluntary basis. While Mexico's crop insurance program still has problems, it offers the best experience for a crop insurance program in developing countries.

Most crop insurance programs are not fully financed by the insured. Therefore, they are government-sponsored rather than operated as private enterprises. The implication is that social benefits justify such public financing. Partial public financing may be essential in less developed countries, but even in Japan the government pays about 60 percent of the premium in addition to administrative costs.

Compulsory participation is a feature of many programs. In some cases this is a part of the connection between insurance and credit. The lender (frequently the government) may look to insurance as a means of improving loan repayment performance. Even if such compulsory insurance benefits the farmer, it may create the impression that the creditor is the intended and chief beneficiary. This may be considered a disadvantage of compulsory insurance that must be offset by advantages such as greater participation and inclusion of normal proportions of high and low risks.

To sum up the lessons from experience, it is noted that crop insurance has been viable under a fairly wide range of conditions. Crop insurance programs have complementary relationships with other activities providing services to farmers. As a result the benefits are intermingled and not easy to measure separately. The relative importance of agriculture in the economics of the least developed countries emphasizes the potential social benefits from any and all good agricultural programs. Benefits to insured farmers, even though small per farmer, are of potential significance because of the near subsistence income levels that are likely to prevail.

These considerations suggest the desirability of crop insurance at an earlier stage of development that that which existed in the United States, and perhaps also Japan, when the present comprehensive government programs were started. There are, however, many things that happen as agriculture develops that make it easier to initiate insurance programs and that increase their chances of success. Included are

development of technical, statistical, and financial services, as well as the creation in farmers of a measure of confidence in the administering government agencies.

Crop Insurance and Technological Progress

Crop insurance, where it has had its greatest use, is one of many financial services to farmers engaged in highly capital-intensive, commercial agriculture, generally with large farm units. Availability of crop insurance may be one of many conditions which enable farmers in developed countries to use the most efficient available technology and continue successfully through good and bad years, without costly disruption of long-term plans. Acceleration of technological progress is not generally considered to be a major reason for public support of crop insurance in these circumstances, although it may have some positive effects on technology.

In the case of small farmers in countries in which there have been only modest departures from traditional technology, crop insurance may be accorded a relatively more important role in stimulating technological advances. Two reasons are frequently cited in support of this proposition. The first is that these farmers are inhibited from making improvements by uncertainty concerning the results. Often this is a matter of lack of trust in whoever may have suggested the new practice. The second, related, reason is that the farmer is so precariously close to a bare survival income level that he has no margin for error. A failure would subject him and his family to severe physical as well as financial hardship.

An important premise underlying the relationship between crop insurance and technological change is that the typical small farmer in developing countries is a rational decision-maker, maximizing his income subject to constraints of risk and the use of some income to satisfy social and cultural demands. The literature on this subject is so extensive that it would require a book just to summarize it. The thrust of this literature, much of it based on empirical research of small farmers, supports the premise of economic rationality on the part of the small farmer, which means that the farmer searches for means to increase his income if given the technology and resources to do so. As with many other economic factors, however, the farmer's desire to increase his income by adopting a new technology is affected (restrained) by other factors, such as uncertainty, perception of higher risk and the need to satisfy claims on his income arising from cultural requirements. The presence of these factors does not mean that the farmer is acting irrationally in terms of maximizing his income.

In an effort to gain further insight into this issue, a statistical analysis was undertaken as part of this study, drawing upon farm survey data for Guatemala and Colombia.[1] The analysis was designed to examine the relationship between variable expenditures of farmers (in other words, those expenditures over which they have control and which can serve as a proxy for their perception of risk) and the yield, returns and level of technology employed. The principal observations from this analysis are that higher

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1. This statistical analysis is described in detail in Annex A.

returns tend to be associated with higher technologies and with larger variable expenditures and there is large farm-to-farm variability in yield for the same crop and technology level (including 10 to 20 percent of farmers who have incomes equal to or below expenditures), which indicates the kind of risk of poor performance that the farmer may encounter. The combination of these two observations in turn suggest that the farmer is rationalizing his decisionmaking in terms of the trade-off between alternative incomes, technologies and levels of risk.

These relationships are illustrated with corn in Guatemala. The mean values of variable expenses, yields and net returns per hectare for each technology class (table II-1) reveal a consistent pattern of increasing productivity and profitability at each technology class over the preceding one; similarly, variable expenditures increase substantially. At the same time, the variability in yields of corn within the same technology class is significant as illustrated in table II-2.

Table II-1. Summary Data for Corn Production in Guatemala

(Per hectare)

Technology class	Variable expenses (quetzales)	Yields (kilograms)	Net returns (quetzales)
1	33	1,163	78
2	74	1,564	94
3	82	1,952	133
4	104	2,444	170

Table II-2. Variability of Corn Yields, Region 6 of Guatemala[a]

(Distribution in percent)

Yields (kilograms/hectare)	Technology class 2	Technology class 4
0-900	19	2
901-1800	64	19
1801-2700	14	44
2701-2600	3	23
3601-4500	0	12[b]
Mean yield (kilograms/hectare)	1,288	2,568

a. Derived from the more detailed distributions in table 8, Annex A.

b. Includes observations with yields greater than 4500.

An insurance program is also an innovation that the farmer has to evaluate as he would evaluate the use of hybrid seed, chemical fertilizer, or insecticides. Much will depend on how well it is explained to him and his trust in the person doing the explaining or in acquaintances who are identified with the program in some way. Well-conceived crop insurance programs are designed using the best available data on the probabilities of crop losses of various specified magnitudes. The usual premise is that the losses covered are those that could not have been prevented by the farmer by the application of average or better managerial skills. The farmer would not be compensated for losses which he could reasonably be expected to avoid.

Managerial skill is related to technology level. Generally if a farmer uses a crop variety with a high genetic yield potential he must use the appropriate kinds and amounts of fertilizer to realize that potential. Weed growth may be stimulated so that more attention must be paid to weed control. Planting, cultivation, and harvest dates may need to be changed. These are elements in a package of practices essential to best results.

At the higher technology and expected yield level, losses may be larger when they occur, necessitating larger indemnities and hence perhaps larger premiums, although this depends on actuarial considerations -- that is, the expected frequency of the larger indemnities. It is implied here that distinctions would be made between different levels of technology for each insured crop.

The offering of insurance to overcome the reluctance of farmers to venture into the unknown has interesting implications. Farmers may have a less-than-adequate basis for evaluating risks than that which is available to those who do the actuarial work on the insurance program. When insurance terms are explained to the farmers, their understanding of risks should be improved, although this may assume too much in terms of the program, the understanding of it by the insurance agent, and the ability of the latter to communicate with the farmer.

Risk as a Constraint on Technological Progress

The utility and feasibility of crop insurance for small farmers rests on another important premise, namely, that the small farmer's perception of risk associated with a new technology is an obstacle to his adoption of the new technology. This is a subject area about which much has been written but unfortunately little learned, and in which absolute classifications are used frequently. Phrases like "small farmers are averse to risk" are common and also misleading; all decisionmakers are averse to risk -- differences are found in the degree of their aversion.

The literature on risk and uncertainty is extensive but little is directed to the role of risk and uncertainty in small farmer decisionmaking and much of that is in turn concerned with theoretical constructs.[1] At the outset it is important to distinguish between risk and uncertainty. Uncertainty reflects what is not known, a state of ignorance of what the possible outcomes of a particular event (such as utilizing a new technology) may be. Risk, on the other hand, reflects an understanding of the possible outcomes, thus permitting the decisionmaker to combine the income of alternative events (say, yields) and the probability of their occurence. The result is often referred to as "expected income." This distinction between risk and uncertainty is important since crop insurance serves principally as a means of reducing farmers' perception of risk rather than as a mechanism for removing uncertainty.

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1. Two good summaries of the literature on risk and the small farmer are Sara S. Berry, Risk and the Poor Farmer, draft report prepared for AID, November 1976; and Development Alternatives, Inc., Small Farmer Risk-Taking, prepared for AID, June 1976.

The more important issue concerns small farmers' perception of risk and how this influences their decisions on the adoption of higher-productivity technologies. The empirical base for addressing this issue is sparse. The variety of studies by anthropologists on the role of risk and small farmer decisionmaking provide insights but tend to be concerned with a limited (and often unique) universe and with a qualitative orientation to the analysis. From these studies we do know that small farmers understand risk, incorporate it into their decisions, and have devised methods to reduce risk (dividing production between cash and subsistence crops, planting a variety of subsistence crops in different ecological zones, utilizing native seed varieties, and socio-cultural strategies which spread the risks to the extended family, a patron or other cultural organizations.[1]

From the same studies we are also able to understand how small farmers perceive risk. The most common hypothesis is that the small farmer perceives risk in terms of avoiding a bad loss which will severely affect his consumption and ability to sustain his future income-earning capacity. This focus-loss concept of risk is attractive, in part because of the intuitive judgment that small farmers who are close to a survival income initially cannot afford the risk of outcomes which have a high probability for leaving them with incomes

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1. Examples of these studies include Frank Cancian, Change and Uncertainty in a Peasant Economy (Stanford, California: Stanford University Press, 1972), and Sutti, R. de Ortiz, Uncertainties in Peasant Farming: A Colombian Case (Atlantic Highlands, N.J.: Humanities Press, Athlone Press, 1973). The papers presented by three anthropologists at a 1-day seminar sponsored by AID(LA/DR) corroborated the observations discussed in the text.

below this survival minimum. The focus-loss concept of risk has been adopted in this study, and is incorporated explicitly in the linear programming model.[1]

Even with this definition of risk the question of how significant a factor risk aversion is for small farmers in adopting a new technology remains. Empirical evidence and quantitative analysis on this issue is virtually nonexistent. This is due in part to the fact that the issue is inherently difficult to quantify. Thus, we are in a position of knowing that risk is a factor in small farmer decisionmaking but are unable to construct the small farmer's risk aversion (or risk-taking) function.

It should also be recognized that risk is only one of several important constraints on adoption of new technology. It may be useful to start by considering the situation in a country or region where farm practices are essentially those handed down from father to son for many generations. Information about new materials and practices spreads very slowly. When extension services are established it is some time before they have much new technology to extend, even if they have the means to establish contacts with significant numbers of farmers. Their stock of information comes first from abroad, then from early work at national or regional research stations or from farm demonstration plots. One of the drawbacks is lack of local information about physical conditions that are important in choosing crops, varieties, rates of fertilizer use, and the like. In other words,

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1. A more detailed discussion of the focus-loss concept of risk is included in Berry, Risk and the Poor Farmer; Development Alternatives, Small Farmer Risk-Taking; and Jean-Marc Boussard and Michel Petit, "Representation of Farmers' Behavior under Uncertainty with a Focus-Loss Constraint," Journal of Farm Economics 49:869-80 (November 1967).

recommendations are not well tailored to local situations. Farmers may discover this in various ways, some of which are painful.

When a farmer has what he considers to be adequate information about a new practice and would like to try or adopt that new practice, it is usually necessary to procure supplies of seed, fertilizer, or whatever else is involved and perhaps also equipment for application of the materials. Many rural areas have very limited distribution facilities for farm supplies, especially those for which demand is still very small. Thus it may be physically impossible or at best very expensive to acquire what is needed.

The next problem may be financial. The old methods may have produced no surplus income which would permit stepping up the rate of production expenditures in the first year of change. Credit is needed, but is not generally available, especially to small farmers who live far from cities or towns in which central or branch offices of credit institutions may be located. Credit from noninstitutional sources may be prohibitive in cost.

There are various marketing as well as production constraints on adoption of new technology. This is especially true if crops of higher value, such as vegetables, are being considered as alternatives to traditional grain crops. Some new technology is generally required to grow these crops successfully and to ensure marketable quality. Higher perishability necessitates greater skill in marketing to avoid serious losses.

The above widely known facts have been accorded this much attention to make the point that risk aversion is only one factor in retarding technological change and that other factors are also of importance.

Nature of Risks and Their Coverage

The complex array of potential risks, their change over time, and their significant variability present an important challenge in the design and successful operation of a crop insurance program. Consequently, it is necessary to examine the nature of risks and their implications for designing a crop insurance program for small farmers with the objective of encouraging farmers to adopt higher-productivity technologies.

Crop yields are influenced by many elements in the physical environment over which the farmer has little or no control. These include too much or too little moisture, high or low temperatures, hail, windstorms, and numerous biological pests. The timing of these phenomena in relation to stages of plant growth is all-important. Farming systems and practices represent some degree of adaptation to these variable conditions. This is a form of risk aversion which may have become conventional or which may be planned by the individual farmer.

Experience and research provide various methods of adapting to a continuously variable natural environment so as to reduce vulnerability wherever possible. Scientists

are constantly at work on varieties of crops that resist certain diseases and are more tolerant of certain moisture conditions. Some hazards are avoided by changing planting data, and varieties are developed with the desired time lapse from planting to maturity. These are only a few of the technological improvements which help to overcome environmental hazards. At the same time the hazards are changing. New pests appear on the scene, and old pests learn to tolerate materials that once effectively controlled them. Soil characteristics are changed by particular crop sequences, and surface water flows and ground water supplies undergo long-run changes. Each farmer has particular soil, slope, exposure, and other features of the natural environment on his farm that interact with natural hazards to increase or reduce their severity and also to condition the advantages or disdvantages of any particular technology.

Data on yields of individual farm crops reflect variations the causes of which are many and varied. Weather-related factors may be virtually uniform over fairly large areas where major physical features are uniform. They change from year to year, and they cause parallel changes from year to year on most farms within the area. Such year-to-year variability is highly significant in crop insurance.

Available data on yields for a series of years are usually in the form of averages for the total acreage of each crop. The averages may be only national aggregates, or there may be disaggregation by administrative subdivision or by area -- seldom by individual farm. As might be expected there is usually a high degree of farm-to-farm variability in yields in any single year, even within relatively small

physically homogeneous areas. The reason is that farmers use different technologies and apply them with different degrees of skill. In addition, there are localized physical differences from farm to farm to which the skillful farmer adapts even within an area that is uniform in macrophysical characteristics.

Various sample surveys in different countries have provided data on crop yields for individual farms in single years.

Survey data for Guatemala and Colombia made it possible to examine yield means and variability separately and comparatively by technology classes. In principle this should identify differences that are attributable to technology, leaving a residual of variability to all other factors.

The analyses of these data do not indicate in general that technologies using more modern inputs give either more or less uncertain results (see Annex A for a detailed discussion). The risk of yields 50 percent to 75 percent below average for a given technology may be no greater -- and it may even be less -- with advanced techniques than with traditional practices. On the other hand, the data for both countries suggest that many modern inputs that were used did not pay off. This was noticeable in Guatemala when participants in the supervised credit program were compared with nonparticipants. Those with ready access to credit apparently were less efficient in the use of modern inputs. In Colombia several technologies in rather wide use did not appear to be economically superior to traditional methods. Farmers either accepted bad advice or they did not follow

good advice carefully enough. These conclusions are from data for only one year in each country, and for that reason they should be considered provisional.

The simplest concept for insurance is that a policyholder will be compensated in cash or in kind for a shortfall yield below a predetermined level the cause of which was beyond his control. While this concept corresponds closely to the farmer's perception of risk (that is, not wanting to incur a loss below some minimum income), it may be complicated in its application by provisions designed to make sure that the farmer cannot gain from neglect of the insured crop. One device for accomplishing this objective is the calculation of indemnities as a proportion of variable expenditures. If the value of the crop fails to cover expenditures incurred in growing it, then the shortfall is covered in full or by some other predetermined percentage. This is intended to ensure that the farmer does all that he can reasonably be expected to do to realize the normal yield that was the basis for setting premium and indemnity rates. Expenditures differ from farm to farm, however, even though essentially the same technology is being used. Some degree of standardization of the terms of insurance policies is necessary for efficient operation. Relating indemnities to expenditures may be looked upon simply as a means of ensuring that crop insurance does not provide incentives to poor performance by farmers or attract participation from more of the less efficient than of the more efficient.

If technological improvement is to be an important objective, greater importance may be attached to adjusting insurance policy terms to categories of technology. To

upgrade technology some additional expenditures are nearly always necessary. It has been reasoned that concern over the variability of returns on these new, higher expenditures may be a deterrent. It is therefore important that insurance terms are such as to make the higher technologies more attractive. Indemnity payments would start at appropriately higher yield levels as levels of technology are raised. The relationship to expenditures would also be taken into account to make sure that farmers would not be indemnified by higher percentages of expenditures at lower levels of technology.

III. ECONOMIC ANALYSIS OF A CROP INSURANCE PROGRAM

The economic analysis of a crop insurance program has two components. The first, and the most important for this study, is a cost-benefit analysis which represents quantitatively the net economic gains (losses) associated with a crop insurance program. The other component is an assessment of other economic impacts of a crop insurance program which are not reflected in the cost-benefit analysis. These include impacts on employment, foreign exchange, savings, availability of capital through credit institutions and income distribution. The assessment of some of these impacts is necessarily qualitative since data are either not available or are severely limited.

Cost-Benefit Analysis

Introduction

Cost-benefit analysis is an analytical tool which enables the comparison of national economic resources required to implement and operate a program (costs) with economic resources generated by the program (benefits). The measure of a program's utility to a national economy (society) is the net benefits, with the program's economic

(social) profitability represented by the net present value or the internal rate of return. In this study, the internal rate of return has been used to indicate the economic profitability of a crop insurance program.

Since the costs and benefits of a program typically occur over a number of years, the time horizon, or economic life, of the program must also be defined. For projects such as roads, irrigation, and electrification, the economic life can easily be determined. This is not the case with a crop insurance program, which requires little in the way of physical structures and consists mainly of ongoing operational activities. Consequently, the definition of a time period in which to assess the costs and benefits of a crop insurance program must be somewhat arbitrary. For this study, a period of 10 years has been adopted.

The economic costs of a crop insurance program will include all real resources used for its design, development and operation. The costs of a crop insurance program will obviously be a function of its size (number of participants), characteristics of the program, and mode of operation. The basic cost categories will include startup costs (both fixed capital and operational), ongoing management, administration, and (potentially) reserves, if by law or for other reasons some proportion of the reserves must be held in a highly liquid form. Premiums paid by the farmer or by some other institution on behalf of the farmer are transfer payments and therefore not part of the economic costs of the program. The specific cost estimates and assumptions underlying these estimates are described in a subsequent section of this chapter.

The benefits of a crop insurance program will correspond to the national development objectives which the concerned country has set for itself. Thus, for example, if a country's sole objective is to increase economic growth, the only benefits of a project would be the goods and services generated by the project. On the other hand, if a country has other development objectives, such as reducing unemployment, increasing foreign exchange, and improving the distribution of income, the impact of any project on these objectives should also be incorporated in the assessment of benefits.

In this study, the benefits incorporated in the cost-benefit analysis are restricted to what we term "aggregate consumption" benefits, or the increased availability of goods directly attributed to the program.[1] For a crop insurance program, the aggregate consumption benefits are the incremental agricultural production, net of production costs, of those farmers covered by crop insurance. The incremental production, or income, is the difference between net production with crop insurance and net production without crop insurance. These benefits have been estimated through the application of the linear programming model for Guatemala. This model, the basic values and assumptions employed, and the results are described in the following section. A more detailed and technical description of the linear programming model is presented in Annex B.

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1. The contribution of a crop insurance program to other categories of benefits is discussed in the latter part of this chapter under "Other Economic Impacts."

Estimation of Benefits

Description of the Model

The linear programming model (henceforth referred to as the crop insurance model) was developed for use in estimating the stream of farmers' net income over time, with and without a crop insurance program. The model selects a set of crop activities[1] on the basis of expected yields, taking into account the farmer's working capital, credit, market prices, and risk considerations. Net income is then calculated on the basis of the achieved yields which occur at the time the crop is harvested. In the without insurance case this is the final net income figure. In the case where crop insurance has been purchased, the farmer's net income is increased by the amount of any indemnities he receives. This process is repeated for each of 10 years with the constraints (working capital costs, credit availability, risk, and so on) in each year adjusted when necessary to take into account the previous year's financial outcome.

The crop insurance model is based on the use of linear programming techniques. Linear programming, a method for determining the best course of action among a large number of alternatives, has three main components: (1) an objective to be met; (2) alternative methods for attaining the objective; and (3) resource requirements and other restrictions which affect the feasibility of utilizing the various methods.

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1. An activity represents a different way of producing a crop and is usually distinguished by different types or amounts of resource inputs.

Within the context of the crop insurance model, linear programming provides a procedure for determining the mix of crop technologies which would achieve maximum net income for the farmer, taking into account the risks associated with each alternative technology.[1] In evaluating each technology, linear programming compares the input resources required (for example, land, labor, materials), with the farmer's ability or willingness to obtain the resources. Where the farmer is averse to the risks associated with a particular technology, the model will exclude the activity from the selection process even though it might be the most profitable. Crop insurance provides a means for loosening the risk restrictions within the model. Thus, depending on the cost of insurance coverage, the risk restriction may be sufficiently loosened so as to bring a formerly risky technology into the final solution. In the context of the model, risk refers to the drop in yields that would occur in a so-called worst year. A high-risk crop activity is so named because of the large drop in yields that will occur in the worst year.

Linear programming also provides a means for analyzing what impact different assumptions might have on the feasibility of crop insurance. Such variables as the availability of credit, farmers' perception of risk, and the level of insurance coverage can be varied over a range of values. By comparing these results one can, for example, see the impact on net income as insurance coverage is increased, or what effect a tightening of credit might have on the farmer who has access to insurance coverage.

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1. Technologies are differentiated by their use of fertilizer and machinery inputs with the lowest technology (1) using none, and the highest technology, both.

The crop insurance model was based on the linear programming model developed by Robert House for analyzing the effects of technology, land, crop mix, credit, and farm size on small farm income employment and production in the Central Highlands of Guatemala.[1] In using the House model, several changes were made to support the analytical needs of the crop insurance study. These changes involved (1) the addition of an explicit risk constraint to simulate farmers' aversion to adopting higher technologies, with the risk constraint defined as the ratio of the worst expected yield to the mean expected yield; (2) the incorporation of a crop insurance program with premium costs determined by the actuarial data of a 10-year yield series and indemnities defined as a percentage of mean expected yields; (3) the addition of a working-capital constraint to simulate the effect of a poor harvest on the subsequent years' production; and (4) the addition of a time dimension to simulate the effects of a crop insurance program over a period of years.

A 1-3 hectare farm was selected for the crop insurance model. A farm of this size was chosen because it represents 38 percent of all farms in the Central Highland, whereas the next largest size (3-5 hectares) represents only 20 percent. Although a single farm size was used to simplify the analysis, House showed in his analysis that net income was essentially proportional to farm size (that is, increasing farm size increases net income in the same proportion).

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1. Robert M. House, "A Linear Programming Analysis of Small Farms in the Central Highlands of Guatemala" (draft report), November 1975.

Results of the Model

The results of the model for the illustrative case, with and without insurance, are shown in tables III-1A, III-1B, and III-2. Tables III-1A and III-1B give net income by crop activity for each of 10 years. The expected net income row refers to the income anticipated by the farmer on the basis of the historical or expected yields. The second row, adjusted net income, is the net income from crop production actually realized. The insurance indemnity row applies only to insured crop farmers and refers to claims paid to farmers as a result of actual yields falling below the minimum guaranteed. The last row, net income, is the sum of adjusted net income and insurance indemnity, if any. Table III-2 presents a 10-year summary of net income by crop and technology class.

In the with insurance case, insurance coverage was offered to the farmer for those production activities which utilized technologies above the lowest level for the following crops: corn, interplanted corn and beans, and garlic. Coverage was set at 50 percent of mean expected yields for each of the covered activities.

In the without insurance case, the farmer's crop activity mix as selected by the model consisted of corn--technology 2 (0.68 hectare), interplanted corn and beans--technology 2 (0.18 hectare), wheat--technology 1 (0.45 hectare), and land rented out (0.49 hectare). With crop insurance, the crop activity mix changed to the following: corn--technology 4 (1.44 hectares), bean--technology 1

Table III-1A. Net Income by Crop and Year, with Crop Insurance
(Quetzales per farm)

Crop activity	Year 1	2	3	4	5	6	7	8	9	10	Total
Beans P12											
Expected net income	10	10	10	10	10	10	10	10	10	10	102
Adjusted net income	22	8	-11	18	-6	6	15	-1	11	18	80
Insurance indemnity	--	--	--	--	--	--	--	--	--	--	--
Net income	22	8	-11	18	-6	6	15	-1	11	18	80
Corn P42											
Expected net income	322	322	322	322	322	322	322	322	322	322	3,217
Adjusted net income	444	604	604	604	444	-47	-47	-47	604	112	3,274
Insurance indemnity	--	--	--	--	--	62	62	62	--	--	185
Net income	444	604	604	604	444	14	14	14	604	112	3,459
Garlic P22											
Expected net income	48	48	48	48	48	48	48	48	48	48	481
Adjusted net income	30	-22	149	122	4	43	-22	30	136	43	515
Insurance indemnity	--	31	--	--	5	--	31	--	--	--	68
Net income	30	10	149	122	10	43	10	30	136	43	583
Wheat P11											
Expected net income	6	6	6	6	6	6	6	6	6	6	62
Adjusted net income	13	-2	2	-1	13	6	9	2	--	6	46
Insurance indemnity	--	--	--	--	--	--	--	--	--	--	--
Net income	13	-2	2	-1	13	6	9	2	--	6	46
Total for all crop activities											
Expected net income	386	386	386	386	386	386	386	386	386	386	3,862
Adjusted net income	510	588	743	743	456	8	-45	-16	750	179	3,915
Insurance indemnity	--	31	--	--	5	62	93	62	--	--	253
Net income	510	619	743	743	461	69	48	45	750	179	4,169

Table III-1B. Net Income by Crop and Year, without Crop Insurance
(Quetzales per farm)

Crop activity	Year 1	2	3	4	5	6	7	8	9	10	Total
Corn P23											
Expected net income	95	95	95	95	95	95	95	95	95	95	949
Adjusted net income	103	229	166	166	166	-24	4	-24	198	39	1,024
Insurance indemnity	--	--	--	--	--	--	--	--	--	--	--
Net income	103	229	166	166	166	-24	4	-24	198	39	1,024
Corn/beans P23											
Expected net income	21	21	21	21	21	21	21	21	21	21	208
Adjusted net income	22	49	36	36	36	-4	2	-4	42	9	224
Insurance indemnity	--	--	--	--	--	--	--	--	--	--	--
Net income	22	49	36	36	36	-4	2	-4	42	9	224
Wheat P11											
Expected net income	39	39	39	39	39	39	39	39	39	39	389
Adjusted net income	80	-15	10	-6	80	36	53	10	2	36	287
Insurance indemnity	--	--	--	--	--	--	--	--	--	--	--
Net income	80	-15	10	-6	80	36	53	10	2	36	287
Total for all crop activities											
Expected net income	154	154	154	154	154	154	154	154	154	154	1,545
Adjusted net income	205	264	212	196	282	8	59	-18	242	85	1,534
Insurance indemnity	--	--	--	--	--	--	--	--	--	--	--
Net income	205	264	212	196	282	8	59	-18	242	85	1,534

Table III-2. Total Net Income
(quetzales per farm)

Crop activity	Technology 1	2	3	4	Total Crop
		Without crop insurance			
Beans					
Corn		1,024			1,024
Corn/beans		224			224
Garlic					
Potatoes					
Wheat	287				287
Total	287	1,247			1,534
		With crop insurance			
Beans	80				80
Corn				3,459	3,459
Corn/beans					
Garlic		583			583
Potatoes					
Wheat	46				46
Total	126	583		3,459	4,169
		Difference (with/without)			
	-161	-664		3,459	2,635

(0.45 hectare), and land rented out (o.49 hectare). With crop insurance, the crop activity mix changed to the following: corn--technology 4 (1.44 hectares), bean--technology 1 (0.18 hectare), garlic--technology 2 (0.036 hectare), wheat--technology 1 (0.072 hectare) and land rented out (0.07 hectare).

The shift to corn--technology 4 and garlic--technology 2, which are relatively high-risk crop activities,[1] was the result of a reduction in the farmer's risk aversion brought about by the availability of crop insurance. The insuring of the high-risk crops provided for a minimum guaranteed yield which served to reduce the risks of corn--technology 4 and garlic--technology 2 to a level comparable with the other lower-risk crop activities. The result of the shift for the 10-year period is a substantially increased net income (Q4,169 to Q1,534, a difference of Q1,534).

A comparison of the actual achieved net income with expected net income for both cases (Figure III-1) shows that in 6 of the 10 years, actual income was above expected income while in 4 it was below, a not unusual result. Further, for the total 10-year period, achieved and expected net income were approximately the same (Q1,534 vs. Q1,545 for the without insurance case and Q4,169 vs. Q3,862 for the with insurance case).

Although it is not known what minimum level of net income the farmer requires to cover unavoidable consumption

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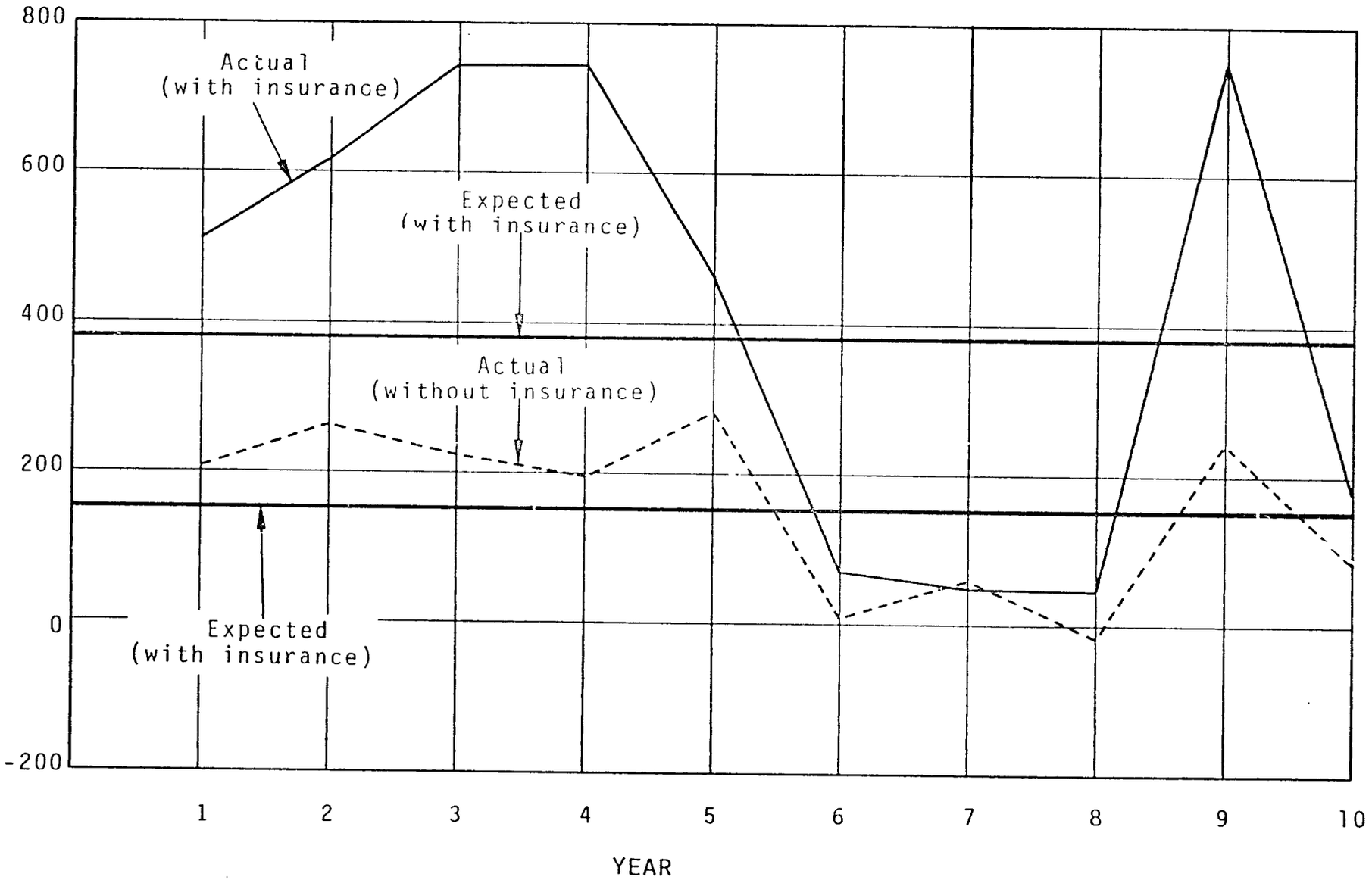
1. To repeat, a high risk crop activity is so named because of the large drop in yields that will occur in the worst year.

FIGURE III-1. COMPARISON OF ACTUAL VS. EXPECTED NET INCOME, WITH AND WITHOUT INSURANCE

(QUETZALES)



and working capital expenses, it can be seen in figure III-1 that under the without insurance case in 2 years (6 and 8) net income was only Q8 and Q18 respectively. For the insurance case, there are several low-income years in a row (6, 7, and 8); however, they are above the lowest year of the without insurance case and are cushioned by 5 preceding years of above-average income.

For the insurance case, indemnities were paid in 5 out of the 10 years, with the lowest payment being Q5 and highest Q92 (figure III-2). In two years (2 and 5) indemnities were paid out even though net income was above average. This was because one of the insured crops (garlic) had very low yields even while corn was enjoying better than average years. In terms of the relationship between premiums and indemnities, in 7 years indemnities were less than premiums, with the result that reserves were accumulated for handling future disasters.

The premium paid by the farmer, which included only the actuarial cost, was Q51 per year (Q44 for corn and Q7 for garlic.)[1] These insurance costs amounted to 18 percent of working-capital costs for corn--technology 4 and 43 percent for garlic--technology 2.

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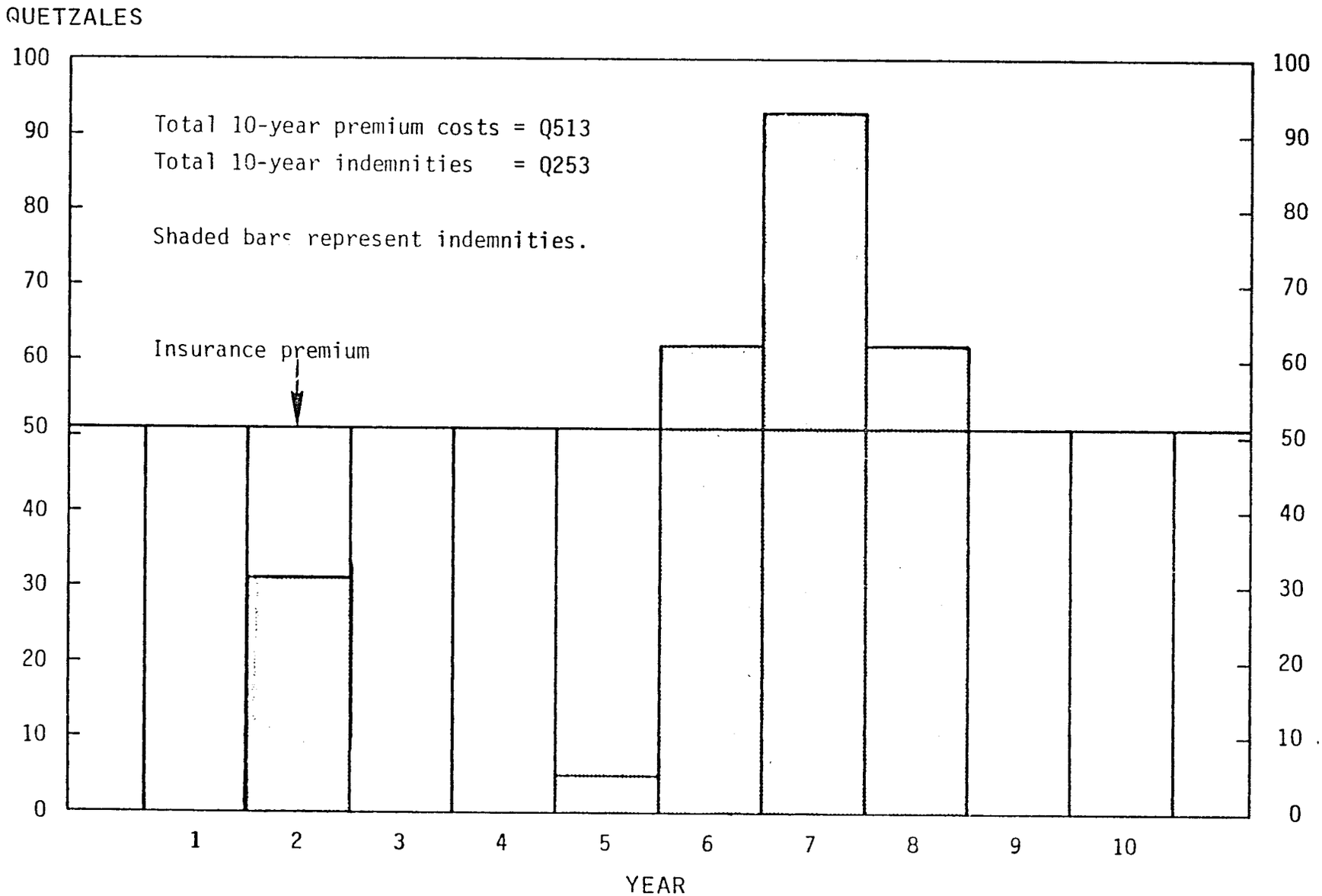
1. Actuarial cost represents the annual expected financial loss for which the farmer is indemnified. Conceptually if we summed up all of the indemnities for a sufficiently long period of time and divided this sum by the number of years we would have the acturial costs. For a more detailed explanation on the calculation of insurance coverage costs refer to Annex B.

FIGURE III—2. COMPARISON OF PREMIUM COSTS VS. INDEMNITIES



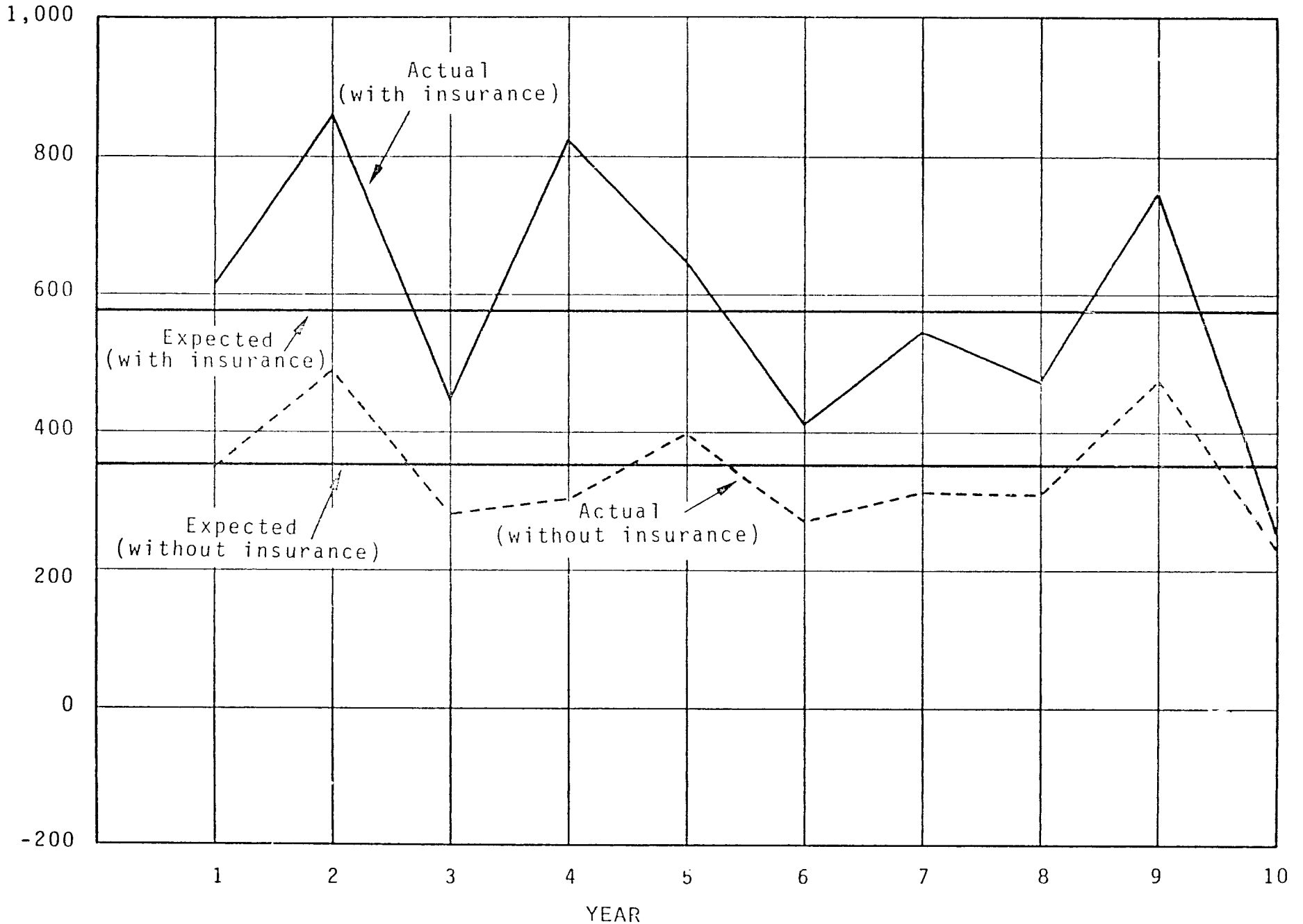
In the cases above, potatoes were excluded from consideration by the farmer even though they were included in the model. This was because it was felt that most farmers were not growing potatoes despite their apparent profitability. For purposes of comparision, however, the model was rerun with potatoes included. The results, which are plotted in figure III-3, show a net income which is considerably higher than the previous cases without potatoes, both with and without insurance. Further, the low net incomes which were in the nonpotatoes cases have been eliminated.

The reason for the improved situation with potatoes is the result of a combination of the higher mean expected net income and the lower probabilities of low yields occurring over time. Potatoes afford the farmer both a higher income and a lower risk situation. To a lesser extent wheat serves the same function. Wheat, like potatoes, has associated with it a relatively low probability of low yields occurring. Without insurance the farmer was able to meet the risk-constraint conditions by growing the maximum allowable limit of wheat as set by the model (25 percent of total hectares). Thus, the wheat provided a form of insurance in the without insurance case. In the insured case, the guaranteed yield level for corn--technology 4, coupled with its higher profitability compared to wheat, resulted in a larger increase in corn area under cultivation and a drop in wheat.

Implications Drawn from the Model

One of the primary objectives in using the crop insurance model was to obtain insights into the important

FIGURE III-3. COMPARISON OF ACTUAL VS. EXPECTED NET INCOME, WITH POTATOES INCLUDED, WITH AND WITHOUT INSURANCE (QUETZALES)



factors affecting a potential crop insurance program. These factors include assumptions concerning the variability of yields over time, the behavior of small farmers with respect to risk, the magnitude of claims in both a single year and over a number of years, the level of insurance coverage required to effect changes in technology, and the financial impacts of a disaster on the succeeding year's production.

The Variability of Yields[1]

Yield information is important to both the farmer and those interested in establishing a crop insurance program. As a practical matter, it is only the low yields and their frequency of occurrence which are important in analyzing the feasibility of crop insurance. From the farmer's standpoint, the key question in assessing the higher technologies is not expected gains, but rather the chances of income falling below some minimum level.

In the without insurance case, net income was below expected in 4 of the 10 years, but only in one year was it negative. Although there is always a possibility of extreme falls in yields the results of the model indicate that the frequency of such falls are likely to be small.

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1. Yield data used in the model are derived largely from the cross-section relationships in the 1973 Guatemala Small Farm Survey. For a discussion of the appropriateness of using cross section data to represent yields over time, refer to Chapter IV and Annex A.

In regard to the impact of yields on the magnitude of indemnities, the model results indicate that large indemnities in any year are likely to be rare, especially in the type of limited program contemplated initially. Although indemnities were paid out in 5 of the 10 years, in only 3 years did yields decline to the level where indemnities exceeded the total premiums paid in the same years.

Farmers' Reaction to Risk

Farmers cope with risk through a variety of methods. The more profitable but higher-risk crop activities were rejected in the absence of crop insurance. Further, there was considerable crop diversification (38 percent in corn, 10 percent in interplanted corn and bean, and 25 percent in wheat, with the remaining 27 percent rented out). Reliance was placed on crop activities with relatively low variability in yields (for example, wheat and corn--technology 2).

With insurance, farmers shifted to the more profitable activities (corn--technology 4 and garlic). Further, there was less diversification (corn now constituted 80 percent of the total). The farmer's former means of coping with risk was supplanted largely by the crop insurance program.

Magnitude of Indemnities

Although indemnities were paid in 5 of the 10 years, they exceeded the premiums paid in only 3 of the years. As a percentage of net income, indemnities were only 6 percent of the total for the 10-year period.

Indemnities were relatively low for two reasons. First, the probability of large drops in yields is low. In the case of the two insured crop activities, corn--technology 4 and garlic, yields fell below 50 percent (the guaranteed level of coverage) only three times.

Second, past experience indicates that a bad year for one crop does not necessarily imply a bad year for other crops. On the basis of this assumption, drops in yields in insured crops will not necessarily occur in the same years, thus resulting in a more even spreading out of indemnities. Of the three times indemnities were paid out for corn--technology 4 and garlic only 1 year was common to both.

Level of Coverage

In the model, insurance coverage is related to mean expected yields.[1] Three levels were used: 50 percent, 40 percent and 30 percent of expected mean yields. Although the base case used 50 percent, the model selected the same crop mix pattern with the 40 percent coverage level. Further, under the assumption of a lower level of risk aversion by farmers, a 30 percent coverage level was able to achieve the same results as the 50 percent and 40 percent case.

Besides the specific risk associated with each crop activity, the amount of coverage also depends on the particular mix of crop activities selected by the farmer. In

1. The reasons for relating insurance coverage to yields rather than, say, expenditures or credit, are discussed in Chapter IV and Annex B. The relationship between these two forms of coverage within the context of the crop insurance model is also discussed in Annex B.

the situation where the farmer combines relatively less risky crop activities with the higher technologies, less coverage will be required. This is because the less risky activities are less susceptible to extreme income losses and thus, like insurance. serve to counterbalance the more risky crop activities.

Financial Impacts of a Disaster on Succeeding Year's Production

Analysis was performed to determine the impact on future production resulting from tighter credit and restrictions on working capital funds. This is important in situations where in one year disaster of such a magnitude occurs that the farmer is unable to pay back all debts as well as maintain minimum consumption and funding needed for the next year's production.

In the model a policy of tighter credit or a reduction in working capital funds will force the farmer to cut back land in production. As restrictions become more severe, there is eventually a shift to the less expensive and less profitable crop activities. Although this applies to both the without and with insurance cases, the impact is greater on the latter because of the higher credit and capital requirements. A drop of 1 percent, for example, in credit in the with insurance case resulted in net income falling 0.8 percent while in the case without insurance the same percentage drop in credit resulted in only about a drop of 0.3 percent in net income.

Specification of an Illustrative Program and Estimation of Economic costs

The computation of the economic profitability of a crop insurance program obviously requires that the economic costs of the program be specified as well as the benefits. In order to estimate program costs, the dimensions of a crop insurance program first need to be specified. Since this study was not directed to any specific proposal for a crop insurance program for any particular country, it was necessary to define an illustrative program. This means, of course, that the results of the cost-benefit analysis should be interpreted with caution.

The two principal dimensions of a crop insurance program are its initial base of coverage (how many farmers will participate) and the rate at which coverage expands over time. In defining these dimensions we established the following assumptions: (1) the crop insurance program is set in a typical small Latin American country; (2) the program would be directed principally if not exclusively to small farmers; (3) the program would be linked formally to (or be dependent upon) an established agricultural service already reaching small farmers, such as a supervised credit program; and (4) the program would be initiated on a pilot basis in order to test operating procedures and the response of the farmers and to gain experience before launching into larger-scale coverage.

The third and fourth assumptions are particularly important since they will have a direct bearing on the feasibility and operational success of a crop insurance

program. For reasons discussed in Chapter IV, it is unlikely that a crop insurance program for small farmers can be established in the absence of other services reaching small farmers. Hence, the rate of growth of participant coverage will depend on the coverage of other services, and in many developing countries these services may only reach a few thousand farmers, with growth taking place at a modest pace. The importance of a pilot program seems self-evident, particularly given some of the demanding operational considerations in crop insurance (discussed in Chapter IV) and the need to avoid mistakes in the early years of the program.

The crop insurance program which has been specified is relatively modest in size (in terms of participating farmers) and rate of growth over time. A higher growth alternative -- assuming a large existing supervised credit base and rapid acceptance of insurance by farmers -- was also specified initially but was not utilized in the subsequent analysis, when the low-growth alternative yielded significantly positive economic profitability. The number of participants by year and the corresponding economic costs for the illustrative crop insurance program are shown in table III-3.

The specified crop insurance program has an initial year designated for design, preparation, and organization of the program. In many circumstances a 2- to 3-year design and preparation period is likely to be required; a separate internal rate of return has been computed under this assumption. There is also a 1-year pilot program involving only 250 farmers; a longer testing period may be realistic and the number of farmers in the pilot program could vary widely from that specified here.

The economic costs of a crop insurance program include start-up costs, ongoing management and administration costs, and (potentially) reserves. As mentioned previously, premiums are not economic costs, since they are only transfer payments, though they are (private) costs to the farmer. Similarly, indemnity payments to the farmer are also transfer payments. The economic costs shown in table III-3 are only approximations, and mainly for this reason the cost parameters have been adjusted under alternative computations of the internal rate of return.

Table III-3. Program Specification and Economic Costs for an Illustrative Crop Insurance Program

Year	Number of participants	Economic costs (U.S. dollars)	Cost per participant (U.S. dollars)
0 (preparation for startup)	--	50,000	n.a.
1 (pilot program)	250	160,000	n.a.
2	1,000	275,000	n.a.
3	2,500	350,000	140
4	3,500	370,000	108
5	5,000	380,000	76
6	7,500	390,000	52
7	9,500	400,000	42
8	12,000	410,000	34
9	14,500	420,000	29
10	17,000	430,000	25

n.a. = not applicable

Start-up costs are difficult to estimate. Capital costs will be small, probably limited to transportation and office equipment. Most of the start-up costs will be devoted to the planning, design, and preparation of the program (identification of zones, type of coverage, and rates, training of field supervisors, and preparation of educational information). The start-up costs are shown as $50,000 for year one, and have been increased to $250,000 and spread over 3 years under an alternative calculation of the internal rate of return.

Administrative costs were estimated through the combination of determining staffing requirements for a program having up to 2,500 participants and the cost experience of the Mexican crop insurance program. Because the Mexican program is both very large (900,000 participants in 1975) and well established (now more than 16 years old), the unit cost parameters from Mexico must be adjusted upward for a new program of smaller dimensions. The administration and management costs for Mexico's crop insurance program are summarized in table III-4. The significant difference in costs between Mexico as a whole and the state of Michoacan is not readily discernible. The difference might be explained in part by the larger average size of landholdings in Michoacan than the national average and in part by the central office and national management costs not included in the Michoacan estimate. Within the state of Michoacan, administrative costs have been reduced significantly with an innovation in management which reduced the need for close supervision of farmers.

Table III-4. Administration Costs for Mexico's Crop Insurance Program
(For 1975 in U.S. dollars)

Cost per participant	22-25[a]
Cost per hectare	
National	7.40
State of Michoacan	
before innovation	4.80[b]
after innovation	2.00
Participants per employee	380

a. Cost per participant ranged from $11 to $25 during 1971-75; the large increase in 1975 cannot be readily explained, aside from the likelihood that more isolated farms were being covered.
b. 1974
Source: LA/DR, Agency for International Development.

Aggregate administrative costs for the illustrative crop insurance program increase during the first 3 to 4 years as the institution develops, but thereafter marginal costs increase at a sharply falling rate; the average cost per participant is $25 by year 11, compared to $76 in year 6. Whether these economies of scale would be as pronounced in reality is difficult to anticipate. On the one hand, the costs of central management would probably remain relatively constant over a wide range of program sizes; on the other hand, as a program extends its coverage to more isolated farms, or to small farmers with scattered holdings, the costs of field supervision will rise. Mexico's cost experience during 1971-75 raises several questions about size and cost efficiencies, but unfortunately it offers only one example for which unique characteristics may be influential.

The capital reserves likely to be created with the introduction of a crop insurance program may also constitute an economic cost if the reserves are held in a highly liquid form. If all reserves are reinvested in the economy, then there would be no economic costs associated with these reserves since the capital would not be held idle. But if part of the reserves are held, say, in the form of cash (whether by conservative management or by requirement of law), then these resources are not available for use elsewhere in the economy, and an opportunity cost must be attached to them. Given the uncertainty associated with this cost element (whether or not reserves would be held in this form and, if so, what proportion and what the opportunity cost of capital would be), it has not been incorporated in the basic cost estimates as shown in table III-4. A separate internal rate of return has been computed by increasing the basic costs by 25 percent, however, with this increase serving as a proxy for reserves held in a highly liquid form.

Results of the Cost-Benefit Analysis

As noted at the outset of this chapter, the economic profitability of the crop insurance program is expressed in terms of the internal rate of return (IRR).

The IRR is calculated by determining the annual interest rate at which the stream of costs, converted to present value, equals the stream of benefits, converted to present value.

The IRR for the base case is 184 percent (table III-5). This return is quite high compared to most projects in

Table III-5. Internal Rate of Return for the Base Case
(Thousands of quetzales)

Year	Base case (potatoes excluded)			Base case (potatoes included)		
	Costs[a]	Gross benefits[b]	Net benefits	Costs[a]	Gross benefits[b]	Net benefits
	1			2		
0	50	0	-50	50	0	-50
1	160	76	-84	160	67	-93
2	275	355	80	275	374	99
3	350	1,328	975	350	415	65
4	370	1,915	1,545	370	1,110	740
5	380	895	515	380	1,280	900
6	390	458	68	390	1,080	690
7	400	-105	-505	400	2,204	1,804
8	410	756	346	410	2,004	1,594
9	420	7,366	6,496	420	3,900	3,480
10	430	1,598	1,168	430	2,176	1,746
IRR:	184 percent			122 percent		

a. From table III-3.
b. Gross benefits are computed by multiplying the difference between net income with insurance and net income without insurance by the number of participants in the program for each year.

developing countries. There are several reasons for this high value. One is the significantly higher profitability of the insured crop activities compared to the present activities. For example, corn--23 and wheat--11, which were the dominant crop activities in the without insurance case, have net returns per hectare of Q138.7 and Q86.4, while corn--42 and garlic--22 have net returns per hectare of Q254.8 and Q1,521.4 respectively. In contrast, when potatoes are introduced, the IRR falls to 122 percent (table III-5) because potatoes, which are not insured, are a profitable and stable crop in terms of yield fluctuations. They thus provide the noninsured farmer with an alternative means for both reducing his risk aversion and increasing his net income without incurring the costs of crop insurance.

Another reason for the high IRR is that the benefits are achieved not only with the crop insurance program but other programs as well. To the extent that additional programs must be undertaken in conjunction with a crop insurance program before farmers are able to adopt the higher technologies -- such as extension and availability of supervised credit -- then the IRR overstates the economic return attributed to crop insurance alone. This problem of isolating a single input where complementary inputs (joint costs) exist is common to many agricultural-related programs.

The economic return may also be overstated because of the assumption in the crop insurance model that farmers without insurance do not adopt higher-technology activities throughout the 10-year period. This may be a reasonable assumption in some circumstances but on the other hand the presence of effective agricultural services could, in time,

lead to adoption of higher-productivity technologies. If this were the case, then the benefit of crop insurance is the earlier adoption of new technology than an would otherwise be the case.

Yet another reason for the high IRR is that the crop price remains unchanged, while in some regions a significant increase in the production of a crop may result in lower prices, thus reducing the level of benefits as shown in table III-5.

In the base case a single specific value was used for key variables such as level of insurance coverage, program costs, farmer's risk aversion, credit availability and working capital constraints. As these factors are particularly important in evaluating the feasibility of a crop insurance program, the values for these variables were changed to determine the impact on the IRR.[1]

1. Insurance coverage. In the base case insurance coverage was set at 50 percent of the mean expected yield for each crop activity. To determine the effect of the level of coverage on the IRR, the crop insurance model was run for two additional levels of coverage, 40 percent and 30 percent of mean expected yields.

The IRRs for the three cases were 184 percent, 192 percent, and -12 percent respectively. The reason for the

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1. The details for the IRR calculations for all the sensitivity analyses are in Annex B, Appendix 5.

increase in the IRR at 40 percent was because the same production income was realized as with the 50 percent coverage while at the same time net premium costs (premiums minus indemnities) were lower, thus resulting in a higher benefit for the same program cost. The negative IRR for the 30 percent coverage was because the coverage level was too low to significantly reduce farmers' aversion to the risks associated with the insured crops. Thus, increases in net benefits did not materialize, resulting in program costs being greater than benefits. It should be noted, however, that under an assumption that farmers are less averse to the risks, the 30 percent coverage resulted in a positive IRR of 51 percent.

2. Program costs. Three alternative assumptions were introduced for the level of economic costs of the illustrative crop insurance program. In the first case, startup costs were increased by from $50,000 to $150,000 and annual costs were increased by 25 percent. In the second case startup costs were increased to $250,000 and annual costs were increased to 50 percent of the base case. The third case specified a 3-year startup period (rather than 1 year as in the base case), with startup costs of $250,000 spread over these 3 years, and annual operating costs increased by 25 percent. The results show a drop in the IRR from 184 percent of the base case to 104 percent, 73 percent, and 73 percent respectively. The implication is that both the magnitude of economic costs and the period required for startup can have a significant effect on the program's profitability.

3. Farmers' risk aversion. The particular level of risk aversion used in the model implies that farmers are

averse to taking significant risks. In the without insurance case, only the crop activities with the lowest degree of risk were selected. As crop insurance was able to provide farmers with a significant level of protection, participating farmers switched to the insured crop activities even though they were formerly the riskiest. To determine the impact of their risk-aversion level on the IRR, additional solutions were generated, with the risk aversion measure made less restrictive in each case. The results of the solutions show a decline in the IRR as risk aversion is reduced.

	Base case	Sensitivity tests (percent)		
		A	B	C
Risk-aversion level[a]	35	33	29	25
IRR	184	156	122	116

a. The ratio of the worst expected yield to the mean expected yield.

4. Availability of Credit. In the base solution a relatively high level of credit is assumed. Aside from the fourth quarter in the with insurance case, when the farmer is unable to meet all of his credit needs, more credit is available than is needed. To determine what impact an assumption of less credit might have, additional solutions were run with reduced credit levels. The results show that the IRRs drop significantly as credit becomes tighter. Although the tight levels of credit still show a positive IRR, they suggest that insurance and credit must go hand in hand to achieve maximum results.

	Base case	Sensitivity tests A	Sensitivity tests B
Change in availability of credit	0	-Q50	-Q200
IRR (percent)	184	154	54

5. Availability of working capital. In the base solution it is assumed that the farmer has sufficient working capital available that he will not be precluded from selecting any activity because of a lack of capital. To determine the impact on the IRR of a situation in which sufficient capital was not available, additional solutions were run with reduced working capital. The results show a drop in the IRR as working capital becomes more constrained.

	Base case	Sensitivity tests A	Sensitivity tests B	Sensitivity tests C
Change in working capital	0	-Q25	-Q75	Q100
IRR (percent)	184	175	125	99

Other Economic Impacts

The introduction of a crop insurance program will have a variety of economic impacts which are not reflected in the results of the cost-benefit analysis. These include impacts on employment, foreign exchange, savings, income distribution, and availability of capital through credit institutions. Most of these impacts are likely to be positive in character, though there can be negative economic implications as well. Each of these potential economic impacts is addressed separately, utilizing data from the crop insurance model in selected cases.

A common characteristic of these impacts is that in absolute terms they tend to be small, despite significant relative changes (such as the percentage increase in employment). The reason is that a crop insurance program of approximately the size specified in this study involves a very small share of farmers in economies where agriculture remains an important sector. In most Latin American countries the proportion of agriculture in total gross domestic product ranges from 20 to 35 percent, while agricultural employment tends to account for 40 to 50 percent of total employment. The impacts of insurance coverage for 20,000 farmers will necessarily be small in comparison to this broader universe. The smallness in absolute terms, however, should not obscure the evaluation of the impacts nor the recognition that most of the impacts are positive.

Employment

Labor surplus conditions are prevalent throughout much of rural Latin America. In Guatemala, for example, the 1973 survey of small farms revealed "unemployment" rates for much of the year in excess of 50 percent. Consequently, programs which are labor-creating have an important positive characteristic.

Under most circumstances crop insurance should lead to increased utilization of labor. Results from the crop insurance model affirm this conclusion, with the average annual man-days of labor for the typical farm increasing from 110 without insurance to 180 with insurance, or an

increase of 64 percent with crop insurance.[1] Much of this labor is in the form of increased utilization of family labor, but some is hired labor, which even the small farmer requires as his planted acreage increases and as his shift to higher technologies demands more labor inputs.[2] While the percentage increase in labor requirements is substantial, the absolute numbers are small (table III-6), even in the context of a moderate-sized country such as Guatemala. The smallness of the absolute numbers, of course, is a function of the size of the program's coverage.

It is recognized that crop insurance may not always generate increased employment. Depending on farm size, additional planted acreage may push a farmer into mechanization which could have a labor-displacing effect. Similarly, some shifts in technology may lead to increased mechanization, again displacing labor. With the size of farms and technology choices utilized in the model, however, one would not anticipate displacement of labor.

Foreign Exchange

To the extent that a country imports or exports agricultural commodities, a crop insurance program will have an impact on that country's balance of payments. Increased

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1. Although the model has limiting fea[illegible] in the way in which it handles hired labor, these results may still be interpreted as reasonable approximations of the labor-creating effects of the crop insurance program.

2. The employment impact can be incorporated into the IRR calculations by applying a shadow, or economic, price of hired labor, with the difference between the market price and shadow price representing the employment benefits of the project (farmer and family labor is already shadow priced in the model). This calculation has not been made in this study.

Table III-6. Estimation of Incremental Employment with Crop Insurance[a]

Year	Incremental man-days of labor	Annual equivalent employment[b]	Ratio of employment to total 1973 agricultural employment for Guatemala
5	245,000	1,633	0.002
9	840,000	5,600	0.007
11	1,190,000	7,933	0.010

a. Derived from the crop insurance model for Guatemala.
b. Assuming 150 man-days.

production attributed to crop insurance may substitute for imports or increase exports. Whether this impact is direct depends on the particular crop insured and the composition of agricultural trade. Were coffee an insured crop, the impact on export earnings would be direct. On the other hand, insuring corn where wheat is the only major food import is not likely to result in an equivalent substitution of wheat imports.[1]

Referring again to the Guatemala example, the foreign exchange impact is likely to be small. While the relative increase in agricultural output is large, the absolute amounts are modest, even for a year in which yields are

1. Foreign exchange costs incurred in the development and administration of the program would have to be subtracted from the foreign exchange gains to derive a net foreign exchange impact. Except where reinsurance abroad is involved the foreign exchange costs of a crop insurance program are likely to be nominal.

Table III-7. Incremental Production with Crop Insurance[a]

(For year 9, in metric tons)

Crop	With insurance	Without insurance	Incremental production
Beans	948	1,680	-732
Corn	88,236	34,140	54,096
Garlic	5,196	--	5,196
Wheat	576	3,744	-3,168

a. Derived from the crop insurance model for Guatemala.

exceptionally high (table III-7). At the same time, the composition of the incremental output (which for the central highland is mainly corn) is not likely to substitute directly for imports or move directly into exports.[1]

Whether the impact on foreign exchange is considered to be beneficial to a particular country depends on the foreign exchange position of that country. For a country with no foreign exchange problem (in other words, where foreign exchange does not have a scarcity value), we need not be concerned with the foreign exchange impact of a crop insurance program. But where foreign exchange is a scarce

1. Guatemala's agricultural exports are predominately cash crops (coffee, beef, cotton, sugar); its imports of agricultural commodities are nominal.

resource, the net foreign exchange impact derived from crop insurance would be considered a benefit of the program.[1]

Savings

A crop insurance program can affect savings in two ways. First, the increased income generated by the participating farmer as a result of crop insurance will most likely yield an increased level of savings by the farmer. Just how much additional savings are generated depends on the marginal savings rate (even if that savings rate is low -- say, in the range of 0.2 -- some savings will be created) and the size of the crop insurance program.[2] To the extent that income is transferred from the government to small farmers by means of the crop insurance program (discussed below), and if the marginal savings rate of the government is higher than that of the participating farmers, the savings impact will be correspondingly reduced.

Channeling a farmer's savings into investment (not necessarily his own but elsewhere in the economy) is necessary if the incremental savings are to have any utility to the economy. Savings which are hoarded have no utility except to the person who is "saving" in that manner. The absence

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1. As in the case of employment, the foreign exchange impact could be incorporated directly into the IRR calculation by applying a shadow price to foreign exchange, with the difference between the market (official) price and shadow price representing the foreign exchange benefits of a crop insurance program.

2. The marginal savings rates of small farmers are likely to vary significantly and could be substantially higher than 0.2. At this rate, the savings created by the illustrative crop insurance program is approximately Q1.5 million in year 9 or about 0.004 percent of aggregate savings in Guatemala in 1974.

of financial institutions in rural areas impedes savings from being translated into investment. Crop insurance may aid in channeling savings, however, by placing a floor on the income of farmers, even in the most disastrous year. Without crop insurance farmers would tend to hold (hoard) their savings for such disastrous years, but with crop insurance, they may be induced to place part of their savings in some other form (bank deposit, government bond, cooperative savings account, and so on).

Savings may also be created if premiums paid by farmers exceed indemnity payments, resulting in the establishment of reserves. These reserves represent financial savings which are available for reinvestment elsewhere in the economy. Whether such reserves will be established, and if so, how large they will be, depends on the relationship of premiums and indemnities over time, which is in turn a function of numerous variables (actuarial base of the premiums, actual yields, and so on).

Income Distribution

If the principal participants in a crop insurance program are small farmers, and if they are part of the low income stratum of the country, then a crop insurance program will have a positive impact on the distribution of income. This impact takes place in two ways. First, and more important, crop insurance enables the average participating farmer to increase his income, not through indemnity payments but by encouraging him to move to more productive technologies which yield higher income. The results of the

crop insurance model illustrate how the income of a small farmer can be significantly increased.[1]

Income distribution also occurs through the likely financing by the government of administrative and related costs. Since these resources are probably general revenues, with the bulk of taxes being generated from the middle and upper income strata, the beneficiaries are the farmers; in effect, they are relieved of a cost which they would otherwise have to incur. The same redistribution effect would occur should the government also pay for part of the premium. As one can see from the illustrative crop insurance program, the transferring of income through government financing of the program is small in comparison to the change in the income of farmers.[2]

There may also be countervailing income distribution impacts. If crop insurance takes the form of ensuring credit, with the insurance permitting higher returns to the suppliers of credit (because of reduced defaults, lower administrative costs, and so on), there will be a corresponding transfer of income to the owners of such capital.

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1. If the crop insurance program covers both large and small farmers, the income distribution effects will not be so readily measured or so significant.

2. How important the income distribution effects are considered to be depends, of course, on the significance which a particular developing country places on income distribution as a national objective. This may range from nominal to overriding importance. In principle, the income distribution effects can also be incorporated into the IRR calculations by applying a weight reflecting society's preference for income distribution to the incremental income of the small farmer. This calculation has not been incorporated here.

If crop insurance is applied to untenured farmers, part of the income gains and transfers (at least 50 percent in most countries) will accrue to the landowners who are not likely to fall in the lower income stratum.

Impact on Credit Institutions

One of the reasons frequently cited for banking and credit institutions not serving small farmers in developing countries is the poor repayment record of small farmers. This in turn is often explained by the limited financial capacity of small farmers; if hit by a poor year they do not have the resources to repay their loans. For a government-sponsored credit institution, created specifically to serve small farmers because other institutions will not, a large proportion of unpaid loans attributable to poor harvests in any one year could lead to partial decapitalization. This in turn would mean either a curtailing of credit in subsequent years or a replenishing of the institution's capital base. Poor repayment could also increase interest rates, further reducing the accessibility of credit to small farmers.

Just how serious this series of events may be is difficult to assess. The empirical base is limited for estimating the extent to which poor repayment impedes the extension of credit, or how serious decapitalization might be. However, it is reasonable to expect that the availability of crop insurance, particularly if linked formally to credit, will avoid the decapitalization problem. At the same time, the availability of crop insurance may induce

other (private) banking institutions to move into or increase their lending for agricultural purposes and specifically to small farmers, which in itself would have a positive effect.

Other Economic Impacts

Crop insurance may have other impacts as well. For example, increased production could lead to reductions in prices of important agricultural commodities. The extent of price reductions obviously depends on the relationship of the increased production to aggregate production, as well as on other relationships between supply and demand. While reduced prices, say for corn, will decrease the insured farmer's income, there will be a corresponding benefit to off-farm consumers of corn.

A crop insurance program with broad coverage of a country's farming community could enable the government to avoid large and unexpected fiscal transfers in the event of serious crop failures. How important this is to the economy depends on the alternative actions the government would take, the severity of the problem, and the fiscal position of the government. Given the likely modest size of a crop insurance program in most developing countries, however, one would not expect a significant contribution to improved fiscal planning of the government.

There will also be impacts on noninsured farmers, impacts which are likely to be negative. If insurance leads to large increases in the output of a particular commodity, resulting in a sharp fall in regional prices for that commodity, the income of noninsured farmers will fall.

Although the income of insured farmers will also be affected, they are likely to be better off than before because their output is substantially higher. When computing the income distribution impacts under such circumstances, the reduced income of noninsured small farmers must be also be taken into account.

Finally, it should be noted that crop insurance may impose distortions in the allocation of the resources of an economy. If crop insurance is provided for only selected commodities, which is likely to be the case in the early years of the program, there will be an incentive for farmers to shift to those crops. Crop insurance intervenes in the market much in the same manner as a price support program or added taxes for specific crops. The extent to which this allocates resources in a different way from what would be the case with a well-functioning market is difficult to estimate.

IV. INSTITUTIONAL CONSIDERATIONS IN THE ESTABLISHMENT OF A CROP INSURANCE PROGRAM

The results of the economic analysis of an illustrative crop insurance program indicate that significant net benefits can be generated by such a program. The internal rates of return are high, even under the rigorous assumptions employed in the sensitivity analysis. The other economic impacts are generally positive, particularly the impacts on employment and income distribution. Yet it is important to recognize that the economic analysis presumed an insurance program, albeit modest in size and growth, which is operational and reasonably efficient (as reflected in operating costs) and one in which farmers are willing to participate.

This is an important presumption, particularly in view of the many institutional and operational considerations which must be satisfied for a small-farmer crop insurance program to function effectively. These considerations are addressed in this chapter. The intent is to identify constraints which will influence the feasibility of such a program and to discuss the more important operational features. It is not intended to provide a detailed prescription for the design and operation of a crop insurance program.

Institutional Constraints

The introduction of a crop insurance program for small farmers will encounter a variety of institutional constraints. Clearly, the design and implementation plan must recognize these constraints and incorporate means to reduce their impact. Five constraints are discussed here: (1) the absence of existing agricultural services effectively reaching small farmers; (2) the limitations in data on crop yields to determine the actuarial base of the program; (3) the presence of traditional methods for dealing with risk; (4) farmers' perceptions of what crop insurance means to them; and (5) the often fragmented and small size of holdings of the targeted group.

Existing Agricultural Services

The dimensions of crop insurance virtually require the existence of other agricultural services, particularly the availability of extension services, material inputs and credit. These services are all the more important if the principal objective of the crop insurance program is to increase agricultural production through the adoption of higher-productivity technologies. The general experience thus far of developing countries including much of Latin America, is that this interrelated package of agricultural services barely touches the universe of small farmers. Generally, existing service agencies will be short of adequately trained, experienced, and capable personnel. There may also be a lack of transportation to get out to and around in rural areas in order to carry on any of the

ongoing activities effectively, and there may be a shortage of supplies and equipment for conducting demonstrations of recommended practices. In brief, crop insurance for small farmers can reach only as far as existing agricultural services.

Furthermore, a crop insurance program may compete with existing programs for personnel, use of physical facilities, and financing. Of these resources, trained personnel who are willing to go out to the small farmer are the scarcest resource, and a well-functioning crop insurance program is dependent on such resources. Hence, it becomes necessary to compare opportunity costs and benefits of using resources in a crop insurance program with the costs and benefits of using the same resources in alternative ways.

Crop Yield Data

Designing an insurance program properly requires a large volume of data not usually available in developing countries. Most conspicuous is the need for representative data on crop yields and their variability on an individual basis, not only in a single year but over a series of years long enough to measure probabilities of crop failures or extremely low yields.

Data are needed for areas small enough that they are for the most part homogeneous, but even with relatively small areas there may be a complex pattern of upland and bottomland and different types of soil that give different yields. Some soils may yield relatively better in rainy years and others in dry years.

The quality and depth of the data base is important in setting premium and indemnity rates and projecting the relationship between premium and indemnity aggregates as it varies over a period of years. This is true no matter what relationship it is planned that total premium collections should bear to total indemnity payments. Costs must be borne by the insured alone or shared in some way with the insuring agency. In any case funds must be available to cover indemnities in bad crop years when numerous or large individual payments are required. If by chance one or more years with yields well below average comes early in the life of the program, an extra strain may be placed on available reserves. On the other hand, if program obligations are met under such conditions, many farmers will have an early demonstration of benefits. The converse would be true if the early years were better than average.

Traditional Methods for Managing Risk

Small farmers may have traditional ways to reduce the risk of suffering inflicted by crop loss or failure. These may include reciprocal sharing among kinsmen, friends, and neighbors to balance out good and poor harvests that have differential local impacts. Tradesmen who sell to farmers or buy from them may assist by deferring farmers' payments or by making advances to farmers who have suffered misfortune. The farmer may be able to square the account or reciprocate in the following year or years, or a one-for-one accounting may not be contemplated, especially among kinsmen. Long-accepted cultivation practices are also employed to reduce risk.

A government-operated insurance program might compete with or be an alternative to such traditional methods of spreading risks. Not only may these traditional methods affect the farmers' willingness to participate in an insurance program, but the demise of these systems may represent a loss to both the farmer and society. The insurance plan must work at least as well as the old system to be called a success. There may be no turning back the clock.

Farmers' Perceptions of Crop Insurance

As noted in chapter II, crop insurance is an innovation to the small farmer just as is a new package of cultivation practices. As with most innovations the typical farmer is likely to be uncertain about the benefits to him of the insurance and whether it is worth the cost of the premium he must pay.

This uncertainty may be accentuated by several factors. One is that crop insurance is by nature not tangible; the farmer cannot see it as he can fertilizer or a new seed variety, and he may therefore have difficulty understanding what crop insurance is.[1] A second factor concerns the time horizon of insurance. Although crop insurance is purchased on an annual basis, the underlying rationale is its applicability over a number of years. It is expected that small farmers in developing countries rarely enter into decisions that extend beyond the immediate cropping year. A third factor influencing the farmer's perception is the administrative requirements of crop insurance, most of which must

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1. This consideration was stressed by the anthropologists participating in the seminar sponsored by AID (LA/DR).

be recorded in writing and through administrators not known to him. The response to these demands by small farmers may well be negative.

Landholdings

"Small farmers" is a generic term referring to a broad class of households. It is also a relative term, both within a given country and between countries of the same region. For this reason we have not attempted to define what constitutes a "small farmer" (though in the crop insurance model a farm of about 3 hectares is specified). Nonetheless, a crop insurance program which is targeted upon small farmers will undoubtedly encounter a constraint in terms of the characteristics of their landholdings.

A large segment of small farmers, particularly in Latin America, are indeed small, with landholdings in the range of 1-3 hectares. Frequently these holdings are fragmented with several plots dispersed over some distance. Communal holdings of land, as in parts of the Andean region and the West Indies, are not uncommon. Sharecropping is also a common characteristic.

All these characteristics of the landholdings of small farmers present potential constraints for crop insurance.[1] Of particular importance are the fragmentation and smallness, since the cost of administration (and possibly the

1. It should be noted that Mexico's crop insurance program has adapted well to the communal system there (ejidos) and has in fact been instrumental in permitting credit to be extended to cultivators of communal land.

physical nonfeasibility of supervising such holdings) may outweigh the economic benefits. Moreover, very small farmers may have neither the cash (or resources in kind) to pay for insurance or the willingness to incur the risk of new technology even with insurance. As a consequence of considerations of administrative feasibility, crop insurance for small farmers may well have to be directed toward those with larger holdings, which means that the lowest income rural households would not participate. There are obvious implications for the distribution of income which follow.

The Operational Features of a "Workable" Crop Insurance Program

To be successful, an insurance program should contribute to agreed-upon objectives in a cost-efficient manner. A central objective is avoidance of distress to farmers as a result of crop failures or subnormal yields caused by forces beyond their control. To the extent that farmers pay premiums to cover some part of the indemnities received, insurance is a self-help device. In the same year some farmers will receive indemnities which may exceed their premium payments while other farmers who also pay premiums receive nothing in return. This is an arrangement to spread the risk whereby the more fortunate assist the less fortunate in a particular year. Over a period of years there should be a rough balancing among farmers. Over time there are years when total indemnities exceed total premiums and vice versa. This implies savings for the system as a whole in good years to cover reduced production in bad years. All insurance programs have these two aspects of reducing farm-to-farm differences in income each year and a programwide balancing between good and bad years.

In addition to these two basic characteristics a "workable" crop insurance program must consider other more specific operational factors. Twelve suggestions are made by P. K. Ray for crop insurance in developing countries:[1]

1. Insurance protection should be limited to crop yields.

2. In the beginning, it should apply only to a few major crops and later others might be brought in as experience is gained.

3. The insurance should be first limited to selected areas, which might be gradually extended should experiences prove favorable.

4. The insurance should apply against all major natural hazards.

5. The insurance may be compulsory or voluntary, depending on the particular conditions and requirements of each country.

6. Protection should be limited to a specified percentage (say 50-75 percent) of the average yield valued at fixed prices; when the cash outlay for the crop can be ascertained, it might not exceed such value.

7. It should at least initially ask for a limited contribution from the farmers, which means that the cost of administration and operation, and even part of the losses, need to be borne by the government.

8. Coverages and premium rates should generally be determined by homogenous areas, and special emphasis should be placed on

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1. P. K. Ray, Agricultural Insurance -- Principles and Organization and Application to Developing Countries (New York: Pergamon Press, 1967), p. 286.

the development of the principle of mutuality and experience-rating within given administrative areas.

9. Adequate incentives should be given to farmers for timely and correct reporting of the acreage under each crop and for keeping losses to a minimum.

10. To keep the cost of operation to a minimum, wherever possible the resources of existing government agencies should be utilized, but the collection of premiums and taxes should preferably to be kept distinct and separate.

11. It should be administered either directly by the government, preferably the department of agriculture, or by an autonomous government institution working with the provincial and local governments, and appropriate cooperative and mutual organizations.

12. It is important to build up an adequate reserve as soon as circumstances permit.

The bases for some of these suggests will be considered further, and other suggestions added.

Insurance Coverage

If crop insurance were to cover losses from low prices as well as low yields, costs would be higher, and the program would be more complex and thus more difficult to administer successfully, as well as more difficult for farmers to understand. If protection against losses from low yields attributable to natural causes only is to be provided, indemnities would be paid on the difference between actual yields and guaranteed minimum yields from

prices chosen at the time that the insurance agreement is signed. Payments in kind or at current prices would incorporate an element of price insurance, which might have merit in selected circumstances.

In the United States, FCI coverage is limited by the amount of the expenses of crop production, not necessarily of the individual farmer, but an average for the area. This may be sound in principle, but it would not be practicable in some situations in developing countries. Production costs may be more variable from farm to farm and may be composed of higher but variable proportions of components such as family labor, which are not purchased in the marketplace. Calculation of indemnities, therefore, as objectively determined physical quantities times predetermined prices, is simpler and probably more equitable.

If a crop is destroyed or seriously damaged by say, hail or a flood early in the growing season the farmer may have sharply reduced costs -- or even no costs -- for the remainder of the season. In principle he should receive a smaller indemnity than the farmer whose loss occurred later after he had incurred more expenses. Such refinements may be essential in large-scale, capital-intensive agriculture, but they might be excessive in developing countries.

In programs with a low degree of rate differentiation and coverage because of a poor data base, there is a possibility that those who usually have above-average yields may be less attracted than those with below-average yields. In this case indemnities per farmer or per hectare might be higher because of the below-average yields of the participants. This might have a negative effect on efficiency in use of resources.

There are two basic issues in insurance coverage. The first concerns the alternatives of insuring the crop or insuring variable expenditures (credit). Insuring the crop, say the mean yield, is more consistent with the hypothesis of small farmer's perception of risk (avoiding losses which will leave them below some minimum income) and hence is likely to serve as a more effective inducement for them to adopt higher-productivity technologies. Insuring expenditures, or credit, does not provide the same protection but is far easier to administer and control. This trade-off between higher benefits and administrative feasibility (costs) is important in the design of a crop insurance program for small farmers.

If the choice is to insure expenditures or credit, then a subsequent issue is to whom the indemnity is paid -- the farmer or the credit institution. Direct payment to the credit institution (as in Mexico) has the advantages of administrative efficiency (hence lower costs) and assurance of loan repayment. The disadvantage is that the farmer may not readily perceive his benefit (indeed, he may perceive the credit agency as the sole beneficiary), which in turn may influence his decision to participate in the program. While direct payment to the farmer should overcome this obstacle, there is no guarantee that he will use this income to repay his loan.

Crops to be Included

Criteria for selecting crops for inclusion must include economic importance in terms of area under cultivation and proportion of farmers involved. The data base is likely to

be better for major crops. A large number of farmers growing a crop in a given area is likely to make for economies in administration, and there will be more farmers to share in benefits as well as to pool the risks.

A multicrop program has advantages in spreading the risks, since in any one year different crops may encounter different combinations and severity of natural hazards. A balance must be struck between the advantage of covering a large number of crops and the dangers of overextending administrative capabilities.

Crops that in the recent past have suffered severe or frequent losses on account of a particular hazard such as hail or windstorm should be included if possible because growers of such crops can more easily be interested in insurance, and their need for insurance is greater. Costs will be relatively high, however, and in extreme situations so high as to be prohibitive. In such cases it may be that the crop is uneconomic in the area because of the frequency of severe losses. Crops that are irrigated and have a dependable water supply are not subject to yield variability on account of drought, something that is characteristic of most crops grown under rainfed conditions.

It is important that the crops that are eligible for insurance be grown on farms that are readily accessible to inspectors. If they are widely scattered, administrative costs are increased. With small farmers as the target group, there will inevitably be a trade-off between greater coverage and higher adminstrative costs.

The operation of a crop insurance program generates highly useful actuarial information that can be used to improve its effectiveness and its equity among participants. This may justify starting out with one or a very few crops in limited areas and gradually expanding as experience points the way. There is always the danger of a bad year early in the life of a program, when adequate provision for meeting obligations has not been made. If the program is still modest in size the government may cover such a situation without undue strain.

Measurement of Yields

There is no simple or accurate way to measure difference between actual crop yields and yields that would have been achieved with average management. For example, to control insects and disease farmers may be expected to use measures that have become generally accepted in the area as a part of good management. Failure to do so should preclude payment of indemnities for such damage. There may be, however, pests for which there are no cost-effective controls, and at any time new pests may appear unexpectedly. If there are no known or immediately available means of control the damage should be covered.

If most farmers in the area control, say, the boll weevil by following a recommended spray schedule, then in principle a farmer should not be insured against damage to his cotton by the boll weevil. But if desert locusts suddenly appeared for the first time in at least a generation and devoured his wheat along with that of his neighbors, he could properly expect a payment if he had all-risk insurance.

The relatively high variability in yields even after observations are sorted and subsorted by characteristics thought to have important effects on yields suggests many variables in the determination of yields. As an example we may take the 52 plots of corn sampled in the Central Highlands region of Guatemala in 1972 at technology level 1 (no modern inputs). The mean yield was 1,196 kilos per hectare but the range was from 150 to 3,250 kilos, and the standard deviation was 619 kilos. This group was not chosen because it was unusual in variability. About 17 percent of the plots yielded less than 50 percent of the mean and might be considered eligible for indemnities under a common type of program. But how do we know to what extent these farmers' yields were depressed by natural causes and to what extent by poor management?

The yield distributions for one year probably are greater than could have been brought about by natural factors alone. To the extent that this is true their use in estimating the cost of insurance programs would result in an overestimate. This may not be inappropriate for a first approximation. It may be better to be able to adjust rates downward or to reduce the public premium contribution as experience is gained than to be forced to go in the opposite direction. The more serious problem is an operational one of avoiding any rewarding of poor management or negligence which might damage confidence in the integrity of the program and actually lower the average level of management.

Complusory or Voluntary Participation

Whether insurance should be compulsory depends on national attitudes, objectives, and agricultural program traditions. Where there is a strong cooperative movement with real participation by farmers there may be a favorable environment for a voluntary program. Where there are strong government controls over area planted in different crops or subsidies of fertilier or other inputs, compulsory insurance may be more acceptable to farmers as only a small extension of government influence over farmers' choices.

If the insurance is compulsory but is not carefully tailored to the differing needs and performances of different farmers, dissatisfaction may be created on the part of farmers who are forced to pay more than the benefits that they receive over a period of years, or at least more than other farmers pay for comparable benefits. This may offer further consideration for government subsidization of premium costs, which tends to characterize the insurance program as one which helps farmers on the lower part of the income scale.

Whether compulsory or voluntary participation is adopted, the use of local organizations of insured farmers to assume some responsibility for the program would be a desirable feature to consider. Involvement of local organizations could reduce the problems accompanying inequities in premiums and indemnities, improve the willingness of farmers to participate, and probably reduce the costs of administering the program.

Premiums

Ray suggests that premium rates per hectare be determined on an areal basis rather than an individual farm or plot basis. This has the advantage of simplifing administration and avoiding the necessity of decisions that farmers may consider inequitable. Equal rates for an area are likely to be inequitable among farmers in the area, however.

For subsistence crops it may be that both premiums and indemnities should be in kind. The farmer then knows the minimum quantity he can depend on, whereas if he were paid in cash the quantity he could buy with his indemnity would vary with the subsequent market price. Premiums designated in kind might also induce a higher degree of response to a crop insurance program.

Small farmers in particular may find it difficult to pay premiums at the beginning of the season, but experience has been that when payment of premiums is deferred, the record of payment is often unsatisfactory. The timing of premium payments is likely to be an important feature in a crop insurance program directed to small farmers. The linkage of insurance and credit can overcome this problem by increasing the credit available to cover the costs of insurance premiums as well as other production inputs.

Reserves against abnormally poor crop years are needed, and they must come initially at least from public sources. In most programs premiums are subsidized to some extent; premium rates need not be set high so as to build up reserves to meet the bad year that might come early in the program.

If the economic benefits of the program are positive -- as the results of the economic analysis suggest -- initial funding by the government would be warranted. In other words, given its broad objectives, the insurance institution need not be commercially viable, since to make it so could require premium payments which would discourage participation and hence result in a reduction in the economic benefits of the program.

Participation of Large Farmers

The focus of this study is on crop insurance as a program oriented to small farmers. This does not mean that a crop insurance program should exclude larger farmers. Indeed, there may be operational and financial advantages to including large farmers in the program. One advantage is that the spreading of the program to larger farmers will increase the insurance base and, assuming premiums are sound actuarially, the financial viability of the program. Management of overhead and capital costs can be more widely dispersed, thus lowering the share of the costs that might otherwise be borne by small farmers.

There are several caveats, however, to the suggestion to include large farmers. If uniform premiums are charged and if these are partly subsidized, there will be a transfer of income to higher income strata of households. Differential premiums could overcome this problem. Also, because of comparative ease in managing and supervising insurance for large farmers, there may be a tendency for the insurance staff to gravitate toward the larger farmer, an experience which is common in the operation of extension and credit services.

Reinsurance

The literature includes references to the possibility of reinsurance facilities on an international scale. The geographic coverage would be wide enough to embrace quite different climates and crops. This appears to have great potential for spreading and balancing risks. It also implies considerable intergovernmental cooperation. Each participating government would have to develop confidence that others would manage their national programs in a financially responsible manner.

In the real world the sequence of events is likely to be, first, the emergence of successful national programs, with the subsequent creation of reinsurance facilities under the sponsorship of an international agency, either one already existing or one to be created for this purpose.

ANNEX A

Analysis of Farm Survey Data

The purpose of this analysis is to present data on crop yield, production expenditure and product value relationships in two countries in such a manner as to facilitate subsequent analyses of crop insurance alternatives. Since crop insurance is being evaluated with special concern for its potential contribution to technological progress by small farmers, the Guatemala and Colombia farm data were particularly relevant. Other analysts had already identified frequently recurring technology categories for each of the important crops and assigned each plot to its proper technology classification. This facilitated the measurement of expenditure levels associated with different technologies and the results measured by crop yields as well as gross value of production and net returns on fixed factors of production.

The data were in a form which facilitated the study of farm-to-farm variability of the characteristics referred to in the previous paragraph. Such variability is of central importance in developing actuarial bases for insurance alternatives.

Technology is considered to embrace the use of new and improved inputs such as fertilizer, new varieties of seed, pesticides, machinery, equipment and irrigation. Technology classes are defined as the use of one or a combination of two or more such inputs in specified quantities. The combinations are chosen on the basis of the frequency of their occurrence on the farms surveyed.

There is a technology 1 category which is essentially the traditional method of producing the crop involving a minimum of purchased inputs. This provides a benchmark for comparison with the various technologies that may be introduced in the belief that net returns will be increased.

Technologies that involve greater expenditures are not necessarily superior. They may be for some farmers but not for others. At the same expenditure level the input combinations may differ, and here again any given combination may not serve all farmers equally well.

Of necessity we must use group averages to show the cost of particular technologies and the results in terms of increased yield and crop value.

The increased value may be compared with the additional cost to see whether there is a net gain and if so how much. But the farmer cannot be certain that he will achieve the average result. In fact most farmers will not. Some will do better and others not as well. In some years most farmers will exceed normal yields, and in other years they will fall short. In spending his own or borrowed money on modern inputs the farmer is concerned with the probabilities

of alternative results. In particular he is interested in the chances of a result so poor that severe hardship would result.

Variability from farm to farm in a single year may be quite different from variability on one farm over a series of years. Variability in crop yields attributable to weather and other natural phenomena, which is usually the focus of crop insurance, is likely to be most pronounced from year to year. Some variability of this kind may show up in farm-to-farm data, and the range of such variability will increase as the size of the area covered increases. In a small area, farm-to-farm differences are likely to be due mainly to physical differences in the land and to differences in the farmers' skills, managerial ability and diligence. Crop insurance programs are not generally intended to cover shortfalls attributable to below average performance by the farmer.

An insurance program designed to limit losses attributable to yield reductions caused by natural factors rather than managerial deficiencies will encounter each year some portion of the kinds of farm to farm variability in yields found in the Guatemala and Colombia data. In years of unfavorable weather or other adverse natural conditions, the variability in yields is in relation to a below-trend mean. In better than average years the converse would be expected. Available crop yield time series for Guatemala as a whole suggest that 1973 may have been slightly subnormal for corn and wheat though not for some of the other crops.

A crop insurance program that did not pay indemnities for yield reductions resulting from substandard management would cost less with any given coverage than the 1973 data indicate for that year. It is this lower aggregate indemnity amount that would rise in worse years than 1973 and fall in better years if distributions about means did not change drastically. Therefore, single-year data are of value if used with considerable care.

The Data Base for Guatemala

A sample of 800 farms in the BANDESA supervised credit program was selected for inclusion in a survey along with an equal number of matching farms not in the BANDESA program. The matching took into account age and education of the farmer, family size, distance of farm from market, farm size, land use, crop mix, and crop yields. The survey was undertaken by the Government of Guatemala and USAID.

A central purpose was evaluation of the BANDESA program by means of comparisons between recipients of credit through that program and those not in the program. Data were available separately for five regions, and costs and returns were shown by individual crops. Farms were subdivided by size groups, but the present analysis is entirely on a per acre basis regardless of either farm or plot size. The several cross classifications which are possible result in some cells with few observations. The standard deviations of the means of key variables are generally relatively high. This is not unusual for such farm data but it does mean that caution is necessary in interpretation. We have looked for broad logical relationships and consistency in patterns rather than small differences in individual means.

Analytical Framework

A basic step is to define technology classes so that plots can be sorted on this basis and mean values and variance of important variables determined by technology class. The work of Robert M. House[1] has been drawn upon for this purpose. While his classification included all plots, in the case of corn and wheat we used only four of his ten classifications that seemed to represent distinct input combinations that occurred frequently. This simplified the analysis at the expense of excluding some plots. Descriptions of technology classes for each crop or combination of crops are given in Appendix A at the end of this annex.

Numbers of observations by technology class for each crop are shown in table A-1. It may be noted that high proportions of such traditional crops as corn and beans were in technology classes 1 and 2. For tomatoes, onions, potatoes, and garlic, on the other hand, high proportions were in classes 3, 4, and even 5.

Table A-2 is presented to show how BANDESA and non-BANDESA plots compare in technology levels. A much lower proportions of BANDESA plots were in class 1 and higher proportions in all other classes except 5. Thus it is clear that there was a positive correlation between BANDESA participation and technology level. This fact alone does not necessarily indicate a causal relationship either way. It will be shown subsequently that some groups of BANDESA

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1. Guatemala Crop Profitability Analysis (draft report), U.S. Department of Agriculture, Environmental Research Service, August 1975.

Table A-1. Distribution of Plots by Technology Class

Technology class	Corn	Wheat	Beans	Sorghum	Tomatoes	Rice	Sesame	Interplanted[a]	Three other[b]
1	289	89	127	31	2	11	16	71	2
2	254	7	58	3	5	23	27	110	7
3	97	84	15	2	39	17	33	24	14
4	139	120	32	3	82	20	--	56	48
5	--	--	--	--	--	--	--	--	15
Total	779	210	232	39	128	71	76	261	86

a. Corn with beans, sesame, or sorghum.
b. Onions, potatoes, and garlic.

Table A-2. Comparison of BANDESA and Non-BANDESA Plots by Technology Class

Technology class	BANDESA	Non-BANDESA
1	140	498
2	291	203
3	202	123
4	324	176
5	5	10

participants had higher expenditures at particular technology levels which often were not more profitable.

The BANDESA/non-BANDESA separation was examined in each case for significance before any use of averages resulting from combination. With regional breakdowns there were usually not enough observations for significance when the two groups were kept separate. Hence most regional differences were analyzed with aggregated BANDESA and non-BANDESA data.

For each group and subgroup, means and standard deviations were calculated for four variables; variable expenditures, yields, gross value of production, and net returns on fixed factors, that is, value of production minus variable expenditures. Particular attention is directed to the additional expenditures associated with higher levels of technology. By comparing these additional expenditures with the accompanying increases in value of production, any superiority of the higher-cost technology can be measured in terms of rate of return on the additional outlays. Such comparisons for one time period are the best available indication of what would happen over time as farmers progressed upward in technology level.

Corn

Table A-3 is presented to show the aggregate results for all corn observations that fall in the four technology classes defined in Appendix A. There is a consistent increase in the means of each of the four parameters from

Table A-3. Combined Data for All Corn Observations

Technology class	Number of observations	Variable expenses		Yields		Gross value		Net returns	
		(quetzales)	(standard deviation)	(kilograms)	(standard deviation)	(quetzales)	(standard deviation)	(quetzales)	(standard deviation)
1	289	33	38	1163	708	111	85	78	85
2	254	74	55	1564	825	168	107	94	97
3	97	82	44	1952	1087	215	140	133	124
4	139	104	51	2444	1503	274	193	170	186

technology classes 1 through 4, even though the standard deviations are high in relation to the means. The general picture is one of increasing productivity and profitability at each technology class over the preceding one.

Table A-4 compares BANDESA and non-BANDESA farm corn plots. Technology classes 2, 3, and 4 are each compared with class 1 in turn. Rates of increase in yields and net returns in relation to expenditures are shown. In all three comparisons the non-BANDESA groups had higher rates of return than the corresponding BANDESA groups. The implication is that the former group used additional financial resources more efficiently. It is not within the scope of this analysis to probe the reasons for this, but the fact itself is of significance in our use of the data. Since only a small portion of all farmers are in the BANDESA program the input-output relationships for non-BANDESA farms may be more significant. While a smaller proportion of non-BANDESA farmers were at the higher technology levels, those who were there were more efficient despite the technical assistance received by the BANDESA group.

Comparing classes 1 and 2 the yield increase was 52 percent for BANDESA farm plots as compared with only 26 percent for non-BANDESA. The rate of return on the additional expenditures, however, was slightly higher (67 vs. 61 percent) for the non-BANDESA group. The non-BANDESA group had lower variable expenditures at technology class 2.

Comparing classes 1 and 3 shows an advantage in favor of the non-BANDESA group in both yield increase and rate of

Table A-4. Comparison BANDESA and Non-BANDESA Farms for Corn Production -- All Regions

	BANDESA			Non-BANDESA		
	Expenditures	Yield	Net returns	Expenditures	Yield	Net returns
Technology class	(quetzales)	(kilograms per hectare)	(quetzales)	(quetzales)	(kilograms per hectare)	(quetzales)
1	36	1059	59	32	1199	84
2	82	1608	87	62	1506	104
2-1	46	549	28	30	307	20
Rate of return on added expenditures			0.61			0.67
Rate of yield increase		0.52			0.26	
1	36	1059	59	32	1199	84
3	81	1749	113	82	2297	167
3-1	45	690	54	50	1098	83
Rate of return on added expenditures			1.20			1.66
Rate of yield increase		0.65			0.92	
1	36	1059	59	32	1199	84
4	106	2332	142	98	2711	240
4-1	70	1273	83	86	1512	156
Rate of return on added expenditures			1.19			1.81
Rate of yield increase		1.20			1.26	

return on additional expenditures. Expenditures for the technology 3 class were slightly higher for the non-BANDESA group.

Comparing class 1 and 4 also shows better results for the non-BANDESA group with respect to both yield increase and rate of return on additional expenditures, although the rate of yield increase is not significantly higher.

Turning to the regional breakdown, it is immediately evident that only regions 5 and 6 have even a possibly significant number of corn plot observations covering all four technology classes, and in region 5 there are only five non-BANDESA observations each for technologies 3 and 4.

Region 6 has yields and both gross and net income well above the average for all regions, while region 5 is closer to the all region average. In both of these regions the non-BANDESA plots produced higher rates of return on additional expenditures associated with higher technology levels for nearly all comparisons. The only exception was technology 2 in region 5. Thus the BANDESA/non-BANDESA relationship described above for all regions taken together seems to persist within regions where significant comparisons are possible.

The corn production data show a consistent pattern of increasing profitability of each technology class over the preceding one despite the relatively high standard deviations of the means. This relationship persists within regions even though the yield level varies from region to

region. There are differences between BANDESA participants and non-participants, but within each group the technology class differences are still observable. This analysis suggests that there is a basis in these data for designing an insurance program for corn in Guatemala which would remove some of the risk incurred in increasing expenditures in order to raise the technology level.

Table A-5 has been prepared to illustrate possible gains in production and income from specified improvements in technology, some of which might be stimulated by an insurance program. In preparing table A-5 some liberties with the data have been exercised in selecting ranges. Instead of depending on standard deviations or other formal measures of variability, we have looked at the means for the different groups and subgroups discussed above. The purpose is only to show orders of magnitude and to emphasize that it is advisable to preserve fairly wide ranges of values in further work of this kind.

Beans

The smaller number of bean observations precludes significant comparisons over as wide a range of alternatives as was possible for corn (table A-6). Net returns for those at technology 2 were lower than for those at technology 1. This is explained by low yields on plots on BANDESA farms and on all farms in region 5.

While technology 3 fared somewhat better than technology 2, it too was less profitable than technology 1 on BANDESA farms. This was also attributable to lower yields.

Table A-5. Comparison of Costs and Returns at Alternative Technology Levels -- per Hectare Corn

Technology class	Variable expenses (quetzales)	Yields (kilograms per hectare)	Net returns (quetzales)
Technology 2 minus Technology 1	24-46	156- 549	1- 28
Technology 3 minus Technology 1	45-63	316- 938	48- 82
Technology 4 minus Technology 1	70-90	414-1083	48-155

Table A-6. Comparison of BANDESA and Non-BANDESA Farms for Bean Production -- All Regions

Technology class	BANDESA			Non-BANDESA		
	Expenditures (quetzales)	Yield (kilograms per hectare)	Net returns (quetzales)	Expenditures (quetzales)	Yield (kilograms per hectare)	Net returns (quetzales)
2 vs. 1						
1	76	1047	217	48	706	161
2	76	743	102	74	754	151
2-1	0	-304	-115	26	48	-10
Rate of return on added expenditures			-			-0.38
Rate of yield increase		-0.29			0.07	
3 vs. 1						
1	76	1047	217	48	706	161
3	72	879	191	95	844	162
3-1	-4	-168	-26	47	138	1
Rate of return on added expenditures			-			0.01
Rate of yield increase		-0.16			0.20	

Continued--

Table A-6. (continued)

Technology class	BANDESA			Non-BANDESA		
	Expenditures (quetzales)	Yield (kilograms per hectare)	Net returns (quetzales)	Expenditures (quetzales)	Yield (kilograms per hectare)	Net returns (quetzales)
4 vs. 1						
1	76	1047	217	47	706	161
4	111	1016	171	79	1155	249
4-1	35	-31	-46	32	449	88
Rate of return on added expenditures			-1.31			2.51
Rate of yield increase		-0.03			0.64	

Technology class 4 made the best showing in terms of yields and net returns, but only for the non-BANDESA group average. The BANDESA group did not show a positive yield response to this or any of the other levels of technology. In region 6, however, where there were 25 technology 4 plots, the results were favorable for both the BANDESA and non-BANDESA subgroups.

A tentative conclusion at this stage is that the data do not provide a satisfactory basis for a crop insurance program for beans, particularly if a major objective of such a program is to improve technology.

Other Traditional Crops

Wheat is the next most important single crop after corn and beans, in terms of numbers of observations, but 88 percent of the observations were in region 1. Nearly all were in technology classes 3 and 4. For all plots in region 1 net returns for class 4 were 53 percent above those for class 1. Yields were higher for class 4, while expenditures were insignificantly lower. House[1] points out that wheat is mainly a small-farmer crop and that the more profitable techniques are fairly labor intensive. This may explain why variable expenditures (not including family labor) are about the same for technology levels 3 and 4. Crop insurance as an incentive to take greater risks would seem to have limited potential in this situation.

Rice, sesame, and sorghum are the other relatively low-value, traditional crops. The numbers of observations are

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1. Guatemala Crop Profitability Analysis, pp. 28-30.

too few to justify detailed analysis. Rice is most important in region 4, where most observations are for technology classes 3 and 4. The next most important region is 5, where technology 2 predominates. This provides little basis for significant comparisons of technology classes. Most of the sesame is in region 4 and in technology classes 2 and 3. Sorghum is the least important of this group of crops.

High Value Commercial Crops

The crops discussed above had net incomes per hectare that average between Q 100 and 200 except for rice at about Q 250. Onions, potatoes, garlic, and tomatoes are of a quite different order of magnitude in value. Net returns averaged from over Q 500 for tomatoes to about Q 1,900 for onions. It has already been noted that these more profitable crops are generally grown with the use of modern inputs. There is of course scope for further upgrading of technology. Only for tomatoes, however, is it possible to demonstrate a clear cut technology-income relationship with the limited data at hand.

Another important question is that of crop mix, particularly when it involves substitution of crops in the higher value for those in the lower value categories. Farmers must risk greater outlays in producing the crops of higher value. It is also of interest to compare degrees of uncertainty in yield expectations.

It is evident that the four crops listed in the lower part of table A-7 have an entirely different order of values

Table A-7. Variable Expenditures, Crop Value Means and Their Variability for Low and High Value Crop

Crop	Variable expenditures (quetzales)	Gross value of crop (quetzales)	Standard deviation as percent of mean
Low value			
Corn	65	172	0.80
Wheat	125	234	0.44
Beans	67	233	1.10
Sorghum	52	182	0.78
Rice	105	356	0.63
Sesame	59	188	0.78
High value			
Onions	636	2541	1.07
Potato	456	1286	0.80
Garlic	512	1772	0.53
Tomato	309	842	1.07

for both expenditures and gross value from those listed in the upper part. The standard deviations of the gross value means, however, do not indicate significantly different degrees of relative variance for the two groups of crops. It should be reemphasized that it is only farm-to-farm variations and not year-to-year variations that are being measured.

The tomato is the only one of the high-value crops with enough observations for possibly significant comparisons. The seven observations of technology classes 1 and 2 taken together do not provide much of a base against which to compare higher technologies. It is clear, however, that technologies 3 and 4 resulted in much higher output, both gross and net, than technologies 1 and 2. This is of course dependent upon much higher input levels. Clear differences in results between technologies 3 and 4 do not show up in the data at hand.

The main considerations confronting farmers in choosing between tomatoes or one of the other high-value crops and a low-value crop may be the great difference in expenditures that they must risk. If crop insurance can eliminate some of the aversion to this type of risk, the potential contribution to output and profits is considerable. It is self-evident that insurance costs and coverage per hectare would be much higher for these crops. There is the problem of high administrative overhead costs and possibly high vulnerability of a program to insure a crop grown by so few farmers.

Farm-to-Farm Variability in Yields

Table A-8 (corn) and Table A-9 (wheat, beans, sesame and tomatoes) have been prepared to show the variability in crop yields within regions and technology categories. The most significant fact is that yields vary over wide ranges within regions even when an attempt is made to take account of the technology variable. Other factors, including physical conditions and skill in the use of particular technologies, must have had very important effects on yields.

The data do not reveal significant distinctions between regions in yield variability. One might expect differences associated with technology, but if they exist, this analysis is not sufficiently refined to reveal them clearly. Much the same conclusion applies to crop comparisons. While the number of observations in some cells is small, and there are some very high yields the accuracy of which might be questioned, we are inclined to conclude that here as elsewhere in the world, results in crop production are highly variable for a large number of reasons. This is an important consideration in designing crop insurance programs.

Distribution of Net Returns

Another major concern in the design of any insurance program is income distribution particularly over the lower part of the range which includes those who might qualify for indemnities. A simple calculation has been made showing for the categories in Tables A-8 and A-9 the proportions that

Kilo-grams per hec-tare	
500	
1,000	
1,500	
2,000	
2,500	
3,000	
3,500	
4,000	
4,500	
Mean	1,
SD/ mean	(

SD = Star

Tab

Kilo-grams per hec-tare	1	3
	Whea	
	1	
500	12	
	26	
1,000		
	24	
1,500	17	
2,000	14	
	6	
2,500	0	
Mean	1,296	
SD/Mean	0.40	

received no net return on fixed factors of production, such as land and family labor. The value of the crop was no greater and usually less than variable expenses. The results of this simple test are presented in table A-10. Typically between 10 and 20 percent had zero or minus net incomes calculated in this way. In region 6 the ratio was less than 10 percent for all technologies. This region also showed up well in this respect for beans. The highest ratio was 23 percent for technology 3 tomato production in region 5. There were scattered cells showing no minus net returns. These observations are suggestive, but should be interpreted with considerable caution.

Analysis of Colombia Farm Data

Detailed farm data derived from a sample of nearly 3,000 farms in Colombia for the year 1969 were made available to us. Analyses somewhat comparable to those for Guatemala were undertaken to throw light on the question of whether findings for Guatemala have significance elsewhere.

Participants in the INCORA agricultural credit program prepare detailed farm plans in support of loan applications. At the end of the year results are recorded, and these provide the data used here.

A classification of technologies used in growing each crop is central to this analysis. The work of James T. Riordan was drawn upon for this purpose.[1] His classification was based on frequency distributions of input patterns

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1. "The Productivity of Colombia Land Reform Beneficiaries: A Comparison with Other Small Farmers in the Colombian Economy" (unpublished draft).

Table A-10. Percent of Observations for Which Gross Value Did Not Exceed Variable Expenses

Technology class	Region 1	4	5	6
		Corn		
1	0	17	15	9
2	13	-	17	3
3	-	15	10	7
4	13	16	19	5
		Wheat		
3	19	-	-	-
4	12	-	-	-
		Beans		
1	-	-	14	0
2	-	-	-	8
4	-	-	-	0
		Sesame		
2	-	18	-	-
3	-	0	-	-
		Tomatoes		
3	-	-	23	-
4	-	-	14	-

for seeds, fertilizer, pesticides, machinery, animal power, irrigation, and labor. For the purposes of the present study the input patterns covered by sufficient observations to appear significant were chosen. The results were as follows:

	Technology class							
	1	2	3	4	5	6	7	Total
Crop	(Number of observations)							
Tomatoes	12	16	12	--	--	--	--	40
Soybeans	17	10	11	--	--	--	--	38
Cassava	148	13	7	9	--	21	--	198
Potatoes	85	101	111	49	74	13	36	469
Rice	87	32	167	28	116	5	36	471
Corn	229	29	307	122	31	57	--	775
								1,991

Note: Specifications for technology classes differ from crop to crop.

In Table A-11, six technology classes for corn are compared with respect to the means of four variables. Class 5 is clearly superior in terms of yield, gross return, and net return, but it requires a higher order of net expenditures. While class 1 shows the lowest mean yield it is second only to class 5 in net returns. This suggests that modern inputs are only profitable in the class 5 combination.

For rice (table A-12) only class 7 is clearly superior to class 1 according to these comparisons of means. For potatoes (table A-13) class 7 shows up best, but classes 6 and 4 also appear preferable to class 1. For cassava there

Table A-11. Corn Yields, Costs, and Returns, by Technology

Technology class	Number of observations	Variable expenses		Yields		Gross value		Net value	
		Pesos	Standard deviation	Kilo-grams	Standard deviation	Pesos	Standard deviation	Pesos	Standard deviation
1	229	413	312	1,037	333	1,373	668	960	664
2	29	432	210	1,178	1,269	1,347	1,289	915	1,272
3	307	530	332	1,094	522	1,216	522	687	400
4	122	614	290	1,057	345	1,362	510	748	439
5	31	1,618	543	2,106	1,053	2,931	1,670	1,313	1,427
6	57	837	264	1,327	475	1,713	645	876	600

Table A-12. Rice Yields, Costs, and Returns, by Technology

Technology class	Number of observations	Variable expenses		Yields		Gross value		Net value	
		Pesos	Standard deviation	Kilo-grams	Standard deviation	Pesos	Standard deviation	Pesos	Standard deviation
1	87	523	299	1,197	380	1,550	538	1,027	438
2	32	644	342	1,242	392	1,544	475	901	487
3	167	590	340	1,165	915	1,439	555	849	417
4	28	2,049	1,233	1,755	1,259	2,592	1,737	543	1,002
5	116	738	284	1,144	283	1,519	463	781	428
6	5	1,540	358	1,380	217	1,540	358	783	237
7[a]	36	5,198	574	4,186	871	7,201	1,573	2,002	1,498

a. Some irrigation.

Table A-13. Potato Yields, Costs, and Returns, by Technology

Technology class	Number of observations	Variable expenses		Yields		Gross value		Net value	
		Pesos	Standard deviation	Kilo-grams	Standard deviation	Pesos	Standard deviation	Pesos	Standard deviation
1	85	4,800	1,337	10,477	2,975	9,257	3,639	4,457	3,152
2	101	3,349	1,681	8,138	5,018	7,493	4,247	4,144	3,045
3	111	6,283	1,315	12,544	3,272	11,185	3,992	4,902	3,442
4	49	4,977	927	10,420	2,108	10,513	2,723	5,536	2,411
5	74	7,682	1,136	13,724	4,017	12,069	3,380	4,388	3,012
6	13	8,799	1,852	14,986	5,679	14,650	6,871	5,851	5,992
7	36	7,747	1,838	15,025	5,896	15,478	3,154	7,732	2,519

is one class that is better than class 1 and for soybeans two. For tomatoes class 1 is shown to be more profitable, even though the two other classes show higher yields.

The provisional conclusion from these comparisions of means of the variables is that the use of modern inputs is only advantageous on a highly selective basis as to the pattern of expenditures on each.

Farm-to-Farm Distribution of Values of Variables

Particular attention has been directed to the distribution of yields and net returns at the lower end of the range, since this is indicative of the pattern of indemnities that would be paid by insurance programs. It should be borne in mind that, as with the Guatemala data, these distributions are influenced not only by weather and other natural factors which might be covered by insurance but also by managerial shortcomings the results of which would not be covered by insurance.

In an overview of the frequency distribution of crop yields it is evident that there is a conspicuous clustering at certain round numbers. For corn--technology class 1, for example, 47 percent of all observations were 1,000 kilos or 1 ton per hectare. For technology 2 the corresponding proportion was 48 percent. It was lower but still noticeable for technologies 3 and 4. Other concentrations were at 1,250 and 1,500 kilos. The same phenomenon was evident in varying degrees for each of the other crops. This suggests that yields reported were often approximations rather than precise figures.

For variable costs and gross value of output there is also evidence of clustering at certain round numbers, but for net returns to fixed factors this does not occur, presumably because this is a derived rather than an independently reported value. There is no evident reason to think that this represents either an upward or a downward bias in the data. Any such bias would call for an explanation not provided by the data.

Variability of Yields

Tables A-14, A-15, and A-16 show variability of yields for the three most important crops by technology groupings. No regional breakdown is available, as in the Guatemala data. This may account for the narrower range of mean corn yields among technology classes. The variability about these means is of the same general order of magnitude as for those in Guatemala.

For rice, technology 7 includes irrigation, and the yields are in a much higher range than that for rain-fed rice. Generally the variability of rice yields is less than that for corn. Even though potato yields in kilograms are roughly ten times grain yields, the relative variability is of the same order of magnitude as for corn.

Net Returns

Proportions with zero or minus crop value above variable expenditures are shown by crop and technology in table

Table A-14. Colombia: Frequency Distribution of Yields
Corn

(Percent of observations)

Kilograms per hectare	Technology					
	1	2	3	4	5	6
Less than 300	1.31	3.45	1.63	2.46	3.23	5.26
300-499	1.75	6.90	1.30	5.74	0	0
500-699	7.86	6.90	4.23	3.28	6.45	7.02
700-899	12.66	13.79	21.17	9.84	3.23	0
900-1,099	49.78	48.28	32.25	40.16	12.90	17.54
1,100-1,299	10.48	3.45	14.01	15.57	3.23	5.26
1,300-1,499	3.06	6.90	7.17	9.02	6.45	1.75
1,500-1,699	8.73	0	13.68	11.48	0	45.61
1,700-1,899	0.44	6.90	2.61	0	0	5.26
1,900-2,099	3.49	0	1.30	2.46	9.68	12.28
2,100-2,299	0	0	0.33	0	9.68	0
2,300-2,499	0.44	0	0	0	0	0
2,500 and over	0	3.45	0.33	0	45.16	0
Mean	1,037	1,178	1,094	1,057	2,106	1,327
Standard deviation/ mean	0.32	1.08	0.48	0.33	0.50	0.36

Table A-15. Colombia: Frequency Distribution of Yields
Rice

(Percent of observations)

Kilograms per hectare	Technology						
	1	2	3	4	5	6	7
Less than 300	1.15	0	2.40	7.14	0	0	0
300-499	0	3.12	1.80	3.57	0	0	0
500-699	1.15	0	4.19	14.29	5.17	0	0
700-899	6.90	9.38	7.78	7.14	10.34	0	0
900-1,099	35.63	21.88	44.31	7.14	32.76	20.00	0
1,100-1,299	34.48	40.62	17.37	3.57	26.72	0	0
1,300-1,499	3.45	3.13	5.39	3.57	4.31	20.00	0
1,500-1,699	6.90	3.12	10.18	3.57	19.83	60.00	0
1,700-1,899	3.45	15.62	1.20	7.14	0	0	0
1,900-2,099	3.45	0	4.79	10.72	0.86	0	0
2,100-2,299	1.15	3.13	0	7.14	0	0	0
2,300-2,499	0	0	0	0	0	0	0
2,500 and over	2.30	0	0.60	25.00	0	0	100.00
Mean	1,197	1,242	1,165	1,755	1,144	1,380	4,186
Standard deviation/ mean	0.32	0.32	0.79	0.72	0.25	0.16	0.20

Table A-16. Colombia: Frequency Distribution of Yields Potatoes

(Percent of observations)

Kilograms per hectare	Technology						
	1	2	3	4	5	6	7
Less than 3,000	3.53	3.96	0	0	1.35	0	5.56
3,000-4,999	1.18	25.74	1.80	0	0	7.69	0
5,000-6,999	2.35	20.79	1.80	0	2.70	0	0
7,000-8,999	10.59	13.86	9.91	20.41	1.35	0	0
9,000-10,999	40.00	11.88	19.82	38.78	14.86	7.69	22.22
11,000-12,999	27.06	8.91	10.81	28.57	13.51	30.77	5.55
13,000-14,999	5.88	1.98	17.12	8.16	18.92	7.69	11.11
15,000-16,999	7.06	6.93	35.14	2.04	40.54	7.69	16.67
17,000-18,999	2.35	1.98	2.70	2.04	2.70	7.69	11.11
19,000-20,999	0	0.99	0.90	0	1.35	15.39	11.11
21,000-22,999	0	0.99	0	0	0	7.69	2.78
23,000-24,999	0	0	0	0	0	0	8.33
25,000 and over	0	1.98	0	0	2.70	7.69	5.56
Mean	10,477	8,138	12,544	10,420	13,724	14,986	15,025
Standard deviation/ mean	0.28	0.62	0.26	0.20	0.29	0.38	0.39

A-17. With three conspicuous exceptions, two technologies for tomatoes and one for rice, this proportion was 16 percent or less. It is interesting to compare these findings with those for Guatamala, especially since different years are involved for the two countries. In both cases the percentages tend to fall in the 10 to 20 percent range.

Table A-17. Colombia: Percent of Observations for which Gross Value did not Exceed Variable Expenses

	Technology Class						
Crop	1	2	3	4	5	6	7
Tomatoes	8	31	50	-	-	-	-
Soybeans	12	10	0	-	-	-	-
Cassava	0	15	14	0	-	0	-
Potatoes	4	1	5	0	8	8	0
Rice	1	3	2	36	3	0	8
Corn	1	7	3	6	16	11	-

Appendix A-1

I. Regions

A. Central Highlands

B. South Coast (West)

C. South Coast (East)

D. Northeast

E. Southeast Highlands

II. Classes of Technology

A. For corn and wheat

1. No modern inputs
2. Fertilizer only or fertilizer and machinery only
3. Fertilizer and improved seed only or fertilizer, improved seed, and machinery
4. Fertilizer and improved seed and insecticides only or fertilizer, improved seed and machinery

B. For corn interplanted with beans, sesame, and sorghum or beans and sorghum.

1. No modern inputs
2. Fertilizer only
3. Fertilizer and improved seed
4. Fertilizer, improved seed, and machinery or insecticide

C. Onions, potatoes, and garlic

1. No modern inputs
2. Fertilizer only
3. Fertilizer and either improved seed or machinery

4. Fertilizer, insecticide, and improved seed or machinery
5. Fertilizer, insecticide, improved seed, and machinery

D. Tomato

1. No modern inputs
2. Insecticide and one other modern input
3. Fertilizer, insecticide, and improved seed
4. Fertilizer, insecticide, improved seed, and machinery

E. Rice

1. No modern inputs
2. Improved seed only
3. Improved seed, machinery, and insecticide only
4. Improved seed, machinery, insecticide, and fertilizer

F. Sesame

1. No modern inputs
2. Improved seed
3. Improved seed and insecticide at least

ANNEX B -- THE CROP INSURANCE MODEL

Introduction

The purpose of this section is to describe the crop insurance model used for analyzing the impact of a crop insurance program on small farmers.

The primary objective of the analysis was to determine the economic feasibility of crop insurance as an instrument for encouraging farmers to adopt higher technology activities. The hypothesis to be tested was that the higher technology-oriented crop activities are superior in terms of increasing farmers' income and production, but that farmers are unwilling to select these crop activities because of the risk of financial ruin were a disaster to occur making it impossible to pay back their costs. From a national standpoint it was further hypothesized that net national income would be higher because the more technology-oriented crop activities are more efficient. Crop insurance in this context is intended as a device to reduce the farmers aversion to the financial risk of the higher technologies by indemnifying farmers when yields fall below the insured level. Thus, the insured crop activities become relatively less risky financially although not necessarily the least risky.

A second objective of the analysis was to identify the factors which would affect the success and failure of a crop insurance program. These factors include, among others, the level of coverage needed, the effect of farmers' aversion, the financial effects of differing yields occurring over time, and, especially, the very low yields.

Crop Insurance Model Overview

The crop insurance model was developed for use in estimating the stream of farmers' net income over time, with and without a crop insurance program. The crop insurance model is based on the linear programming model developed by Robert House of USDA/ERS, for analyzing the effects of technology level, crop mix, credit and farm size on small farm income, employment and production.[1]

Two basic versions of the crop insurance model were created, the first without a crop insurance program and the second with a program. The basic model selects a set of crop activities on the basis of expected yields taking into account the resource, financial, marketing and risk aversion constraints imposed on the farmer. Net income is then calculated on the basis of the achieved yields which exist at the time the crop is harvested. In the without insurance case this is the final net income figure. In setting up the model the 1-3 hectare farm was chosen to serve as a proxy for small farms.

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1. Robert M. House, A Linear Programming Analysis of Small Farms in the Central Highlands of Guatemala (draft report, November 1975).

In the case where crop insurance has been purchased the farmer's net income is increased by the amount of any indemnities he receives. The process is then repeated for a second time period with the various constraints adjusted to take into account the previous year's net income. A new set of crop activities is then selected and net income calculated using the achieved yield applying to the period of time. By repeating this process over a period of years, a time stream of farmers' net income is obtained.

The crop insurance model contains the 33 production activities included in the House model. Activities represent different ways of producing a crop and are usually distinguished by different types or amounts of resource inputs. A few of the activities have, however, been excluded from entering the model solution because they appear to represent atypical situations. The production activities cover six crops which were observed in the Central Highlands Region (see Appendix B-1). These crops are bean, corn, interplanted corn and beans, garlic, potatoes and wheat. Table 2B-1 (Appendix B-2) contains for each activity the cost and income factors used in the model.

Each of the 33 crop activities has been classified by type of technology on the basis of the presence of fertilizer and machinery inputs. A higher technology is assumed to be a more profitable method of production. Although this is generally the case, there are, among the 33 activities, higher technologies which are inferior to lower technologies in profitability. This may be because of a misapplication of certain factor inputs or because of the high cost of production in relation to additional output gained. The

crop insurance model will, however, reject any inferior activity, no matter what its technology level. Table B-2 gives the number of activities by technology class and crop.

The House model uses a single set of production yields in determining net income. In the crop insurance model three sets are used: The first set represents the so-called worst yields which the farmer might expect in any year. The second set represents the yields which the farmer expects to occur based on the experience of past years. The third set of yields represents the yields actually achieved at the time of harvest.

Table B-1. The Number of Activities by Crop and Technology Class

Crop	Technology Class 1	2	3	4	Total
Beans	2	1			3
Corn	3	4		3	10
Corn/Bean	2	3			5
Garlic		2			2
Potatoes	1	3			4
Wheat	1	4		4	9
Total	9	17	0	7	33

In the crop insurance model any of the 33 production activities (with a few exceptions) can be selected by the farmer. This is a significant change from the House model in which only those production activities in a single technology level can be selected. The removal of the restriction on technology levels requires the addition, however, of a measure of the aversion of farmers to take on the financial risks associated with the higher technologies.

The introduction of the risk aversion constraint in the model has two purposes. First, it allows the farmer to select the higher technologies whenever his risk aversion to these activities can be sufficiently reduced. And second, it permits one to simulate the potential impacts of a crop insurance program on reducing risk aversion and in turn the adoption by the farmer of the higher technology production activities.

A crop insurance program has been incorporated into the model in order to simulate the effect such a program would have on encouraging farmers to adopt the higher technology production activities. The insurance program is designed to indemnify the farmer in the event that the net income of the insured activity falls below a guaranteed minimum level. In the model, insurance is available for selected higher technology activities. It is assumed that given sufficient protection from certain losses, farmers' risk aversion can be reduced to the level at which the higher income advantages outweigh the possible risks. For each specified level of insurance coverage, an insurance premium cost is calculated solely on the basis of actuarial methods. It is assumed

that administrative costs associated with an insurance program will not be borne by the farmer. As such, the cost of the premium, over a sufficiently long period of time, will be equal to the amount of the indemnities paid back to the farmer.

The following parts of this section give a more detailed description of the model and data construction.

Concept of Risk within the Crop Insurance Model[1]

It is assumed that farmers choose among various possible actions the one which will maximize their expected net income provided that the possibility of net income falling below a minimum level is negligible. Emphasis within this concept is placed on avoiding possible ruin rather than on achieving the highest possible gains.

Risk within the context above is determined by two factors, a minimum level of income and the likelihood of that income level not being reached in any year. The minimum income level is defined to be that amount of income which is required by the farmer to cover all unavoidable expenses, namely minimum consumption and sufficient working capital to continue production.

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1. This section draws on the article by Jean-Marc Boussard and Michel Petit, "Representation of Farmers' Behavior under Uncertainty with a Focus-Loss Constraint," Journal of Farm Economics 49:869-80 (November 1967).

The second factor involved in defining risk deals with the probability of income falling below a minimum level in any year. Associated with each crop activity there is a distribution of possible yield outcomes running generally from zero to some relatively high limit. By multiplying the yields times the price per hectare it is possible to arrive at the distribution in terms of income. For each income level there is a probability of that income not being met over a given time period, say three times in ten years. Where the probability is very small, it is often assumed that the risk of such an event happening can be neglected for practical purposes.

What we have attempted to do with the crop insurance model is to determine, for each crop activity, a yield, below which the probability of its occurrence is so small that it can be ignored as a likely possibility. For this purpose we have, as suggested by others, assumed that all catastrophic yields whose frequency of occurrence is less than once in ten years be ignored.[1]

Combining the concept of minimum income and negligible risk together we propose to define the risk associated with a given crop activity as the relative difference between the so-called minimum expected income (that which would occur in one year in ten) and the mean expected income measured as the ratio of the two. The ratio itself gives the expected percentage of income that would result in the so-called worst expected year.

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1. This is the same assumption used by Boussard and Petit.

In comparing two crop activities within the crop insurance model it is assumed that the least financially risky of the two is the one in which the ratio of minimum to mean income is closest to 1.0. As the expected income for two crops are likely to be different it is true that under this concept the crop with the highest ratio may not be the one with the highest expected income. This would be the case, for example, were minimum and mean income to be 10 and 40 for one crop and 5 and 10 for the other. It is argued, however, that it is the relative difference rather than the absolute difference which is important. (A person with a higher income also generally has a higher minimum level to protect.)

Concept of Crop Insurance within the Crop Insurance Model

Crop insurance is intended as a mechanism to encourage farmers to adopt the higher technology oriented crop activities by providing protection from the financial effects of occasional low yields. This is somewhat different in purpose from the more common use of insurance, which is to protect one's assets or investment from large but infrequent losses by spreading the losses (in the form of premiums) over a period of time.

As developed earlier, the risk of the farmer is defined in terms of the probability of having his income fall below a minimum amount. It is generally the case that the higher technologies, although they are more profitable, involve somewhat more risk. Before the farmer will adopt any higher technology, his risk aversion must be sufficiently reduced

so that his chances of being ruined have not been increased. Within the crop insurance model, this is done by guaranteeing the farmer a minimum yield sufficiently high that with the inclusion of the insured activity his overall risk level has not been increased in relation to what it was with the lower-technology activities. Operationally this is accomplished by replacing, for the insured crops, the so-called worst yield with the insured minimum guaranteed level.

Where the amount of hectares in production for each crop is fixed, the amount of coverage required to bring in a new crop activity as a replacement can be determined in a straightforward manner. Where the new crop activity would generate a different production mix (in hectares), however, which is generally the case, then the optimum coverage can generally only be computed by trial and error.

The cost of crop insurance paid by the farmer (in the form of an annual premium) has been assumed to be based on the potential indemnities only. The administrative costs have not been included in the premium cost.

The premium which is computed on an actuarial basis will, over a sufficiently long period of time, be roughly equal to the average indemnity paid to the farmer.

Table B-2 gives the premium cost for each of the insured crop activities for 30 percent, 40 percent, and 50 percent levels of coverage. The premium cost was based on the assumption that whenever a yield falls below the insured

level it would on the average drop to the midpoint of the insured range. For corn-42, as an example, at the 50 percent level of coverage the cost of insurance would be calculated as follows:

1. Probability of yields falling below 50 percent of mean expected yields is 29 percent on the basis of the yield-distribution table.

2. The expected loss if the yield should fall below 50 percent is equal to the midpoint of the range (25) times the mean expected income, which is 426.7 quetzales.

The costs of insurance is thus .29 × (25 × 427.7 quetzales) or 31.01 quetzales.

The probabilities of actual yields being less than the insured guaranteed level were computed from the set of yield frequency distributions derived from tables B-2 through B-9.

As indicated above, the level of insurance coverage was set as a percentage of mean expected yield. The result is a situation where the guaranteed yield times the selling price can be greater than both the farmer's net income and his expenditures. This is seen below, where the three levels of coverage are presented as a percentage of farmer's expenditure level and farmer's net income for three crop activities:

Activity	Insurance coverage as a percentage of mean yields		
	30	40	50
	Coverage as a percentage of expenditures		
Corn-23	58	77	96
Corn-42	74	99	124
Garlic-22	105	140	175
	Coverage as a percentage of net income		
Corn-23	63	83	104
Corn-42	50	67	84
Garlic-22	42	56	70

Although it may be preferable to limit coverage to an amount that does not exceed a given percentage of expenditures, this could cause failure of a crop insurance program to achieve its objectives. Exactly what level of coverage would induce farmers to innovate is related much more to net income or to yield than to expenditures. If the level of coverage were set in relation to expenditures, therefore, the result might be a level too low to reduce the farmer's aversion to adopting the newer technology.

Table B-2. Annual Premium for Crop Insurance
(Quetzales)

Crop activity	Guaranteed level (in relation to mean expected yields)		
	30 percent	40 percent	50 percent
Corn-21	3.13	5.68	9.94
Corn-22	3.49	6.35	11.10
Corn-23	4.78	8.69	15.20
Corn-42	10.91	18.82	31.01
Corn-43	7.28	12.55	20.68
Corn/Bean-21	6.38	11.60	20.29
Corn/Bean-22	2.56	4.65	8.14
Corn/Bean-23	3.83	6.97	12.20
Garlic-21	52.99	100.40	162.69
Garlic-22	60.74	115.09	186.49

Premiums = (Probability of yield below guaranteed level) × (Midpoint of guaranteed yield) × (Mean income)

Determination of Crop Activity Yields

The crop insurance model selects the crop activities on the basis of farmers' expectations of yields, but calculates net income on the basis of the actual achieved yields which exist at the time the crop is harvested. In all, three sets of yields are required by the crop insurance model. These are:

1. the mean expected yield
2. to so-called worst yield
3. the actual achieved yield.

In order to generate the three yields, a yield distribution curve for each of the 33 crop activities reflecting the frequency over time of specific yields occurring was developed. As was explained earlier, yield data over time were not available, and it was therefore necessary to use the cross-sectional distribution of yields as a proxy. Further, in cases where the cross-sectional data for a given crop were insufficient, the distribution of a similar activity crop was used as a proxy.

As a starting point, cross-sectional yield data were developed by crop and technology class using the Guatemala Small Farm Survey data and the Colombia INCORA data bases.

In order to generate a frequency distribution, the yields were grouped into yield ranges with the number of observations for each group computed. For each yield range group three computations were performed:

1. observations were converted into a percentage of total observations;
2. the midpoint yield of each range was determined;
3. the midpoint yield was divided by the mean yield of all observations to arrive at a percentage of mean yield value.

The percentage midpoint yields were then graphed to produce a continuous frequency distribution. (Figure 3B-1 in Appendix 3B, shows the distribution curve for corn-42 as an illustration.) It should be pointed out that by generating the distribution in relative terms it was possible to minimize certain problems involved in incorporating data from different sources. Further, under the assumption that relative yield distributions of two different crops or technologies may be similar even though their yields were not, it was possible to assign a proxy distribution to a crop activity where insufficient data existed. This is particularly true in the cases of garlic, where tomato was used as a proxy, and potatoes, where the Colombia data was used.

Using the yield distributions, it was then possible to generate the three yield sets, namely the mean expected yield, the worst yield, and the actual achieved yield. The expected yield is the same set of yields in the House model. In terms of the yield distribution it is theoretically the average yield; as seen in the yield distribution table, however, it is slightly less than the mean. This is due to the fact that extremely high yields (generally those with a percentage of observations of less than 1 percent) were eliminated without subsequently adjusting the overall distribution mean. As the deviation was generally small it was not felt necessary to correct the expected yield to correspond exactly to the mean yield.

The so-called worst yield is the decennial catastrophe. This is equivalent to the 0.1 frequency yield as computed from the yield distribution.

The actually achieved yields were derived from the yield distribution by selecting at random one yield from each year of the analysis. In order to facilitate the random yield selection the yield distribution was converted into a cumulative frequency distribution in such a way that the probability of picking a yield was proportional to its frequency of occurrence.

The individual yield distributions are shown in tables 3B-2 through 3B-9. Table 3B-1 indicates the specific yield distribution assigned to each crop activity.

Construction of the Crop Insurance Model

The crop insurance model is based on the linear programming model developed by Robert House for the Central Highlands of Guatemala. In using the House model, a number of changes have been made to support the analytical needs of the crop insurance study. These can be summarized as follows:

1. The House model does not permit the farmer to change production technologies. In the crop insurance model the technology restriction has been eliminated. To take into account the assumed risk aversion of farmers towards the higher technologies a risk aversion constraint function has been added. This constraint basically says that farmers will select activities in which the probability of net income falling below a minimum level is negligible. Mathematically this is constructed by computing the ratio of the sum of the worst expected income to the sum of the mean

expected income for the set of crop activities being considered for selection. The ratio of the two sums is then compared with the particular risk aversion factor being assumed. In running the model a base value of 35 percent (worst expected income divided by mean expected income) was used. Where the computed ratio value is less than 35 percent, the solution is unfeasible and a new set of activities must be selected and tested.

2. The House model contains a single set of yields for individual production activities reflecting those of a given year (that is, 1973). This yield set is used for both selecting the set of activities to be produced and for calculating net income. In the crop insurance model, three sets of yields are used. The first yield set is used in determining the worst expected income. Within the model it is expressed in the form of a set of technical coefficients. The second yield set is used in computing expected net income and is the basis for crop selection. These yields, also expressed as technical coefficients, are the same as presented in the House model. The third yield set, used to compute actual net income, is in a report writer, rather than in the optimizer. The actual achieved yields are provided for each crop activity for each of 10 years.

3. A crop insurance program has been incorporated into the model. In so doing, the following modifications were made to the House model. First, a new row was added to reflect the cost of the premium in relation to each of the insured crop activities. Second, for the insured crop activities the technical coefficient representing the worst

income has been replaced by the guaranteed insured level. And third, an equation has been set up in the report writer to compute the amount of indemnities, if any, to be paid out to the farmer.

4. A working capital constraint function has been incorporated into the model to simulate the effects of a disaster on the selection of next year's crop activities. As the crop insurance is now constructed, decreasing the amount of working capital will result in the employment of lower-costing technologies which are generally less profitable. On the other hand, increasing the amount of working capital will generally have no effect on crop selection unless certain other constraints are also changed, such as farm size, credit availability, or risk aversion. Within the model the constraint is expressed through a set of technical coefficients representing the working capital needs of each crop activity.

5. In the House model, time is essentially held constant. The model was not designed as such to simulate the impact over time on net income from changing certain model parameters. To attempt to simulate the effects over time of a crop insurance program on net income, a report writer was added to the model.

The report writer determines net income on the basis of achieved rather than expected yields for each of ten years. For each year that the same crop mix is assumed, however, the achieved yield will be different as will the amount of any insurance indemnity. In addition, it is possible to

change the basic crop mix to reflect a build-up in assets, changes in the risk aversion, a fall in working capital brought about by a disaster, and so forth. This is done by manually combining the results of different report writer runs.

The report writer, as it is now programmed, extracts from the linear programming solution the number of hectares of each of the crop activities to be cultivated. Tables have been set up within the report writer, containing for each activity (on a per hectare basis), the following: production cost, insurance premium cost, expected production income, minimum guaranteed income for insured crop activities, and a production income selected at random for each of the ten years. For each crop activity the following items are calculated:

- the expected net income
- the actual net income before any indeminities, if any, are paid out
- the amount of any indemnities
- the actual net income including any indemnities paid out.

Each item for each crop activity is totaled to arrive at a 10-year total. All crop activities are then totaled by each item to arrive at an overall total for each year including the overall 10-year grand total. The annual overall total of net income including indemnities is then used in the cost-benefit analysis.

Appendix B-6 contains the linear programming tableaux; Appendix B-7 contains the report writer program.

Calculation of Internal Rate of Return and Sensitivity Analysis

The methodology for the calculation of the internal rate of return used in the cost-benefit analysis and summary of results were discussed in chapter III. The detailed results of the IRR calculations are presented in Appendix B-5.

In order to determine the impact different assumptions would have on the results of the crop insurance model, a sensitivity analysis was performed. The analysis consisted of rerunning the crop insurance model for a range of values for various model parameters. The parameters in the analysis included the following:

- credit availability
- farmer's overall risk aversion level
- working capital availability
- level of insurance coverage

The level of credit availabliity was set at Q524 per quarter. In the with insurance case this limit was reached only in the fourth quarter. In the without insurance case, the maximum credit required in any quarter was Q288. In the sensitivity runs the level of credit was changed in increments of -Q50 starting at Q524 for the insurance case and Q300 for the without insurance case.

The level of risk aversion was set at 35 percent for both the with and without insurance cases. In the sensitivity runs, the risk aversion level was changed in increments of -2 percent down to 25 percent.

The level of working capital was set slightly above the maximum requirement of the base case. In the sensitivity runs the level of maximum working capital was changed in increments of -Q25 starting at Q350 for the with insurance case and Q200 for the without insurance case.

In the base case insurance coverage was set at 50 percent of the mean expected yield. In the sensitivity runs the level of coverage was changed to 40 percent and 30 percent.

In addition to the above sensitivity runs, a limited second set of runs was made in which potatoes were allowed to enter the solution.

The results of the sensitivity analysis are in two parts, the first part (tables 4B-1 through 4B-4, Appendix B-4) lists the crop activities selected, the resulting net income (based on the expected yield) and the rate of change in net income in relation to the rate of change of the parameter changed. The second part (tables 4B-5 and 4B-6) gives the stream of net income over the 10-year period of analysis.

APPENDIX B-1

This appendix contains a list of crop activities used in the crop insurance model. The crop activity name is composed of three parts. The first part is the name of the crop and is abbreviated as follows:

Beans	-	BEAN or B
Corn	-	CORN or C
Interplanted Corn/Beans	-	CN/BN or N
Garlic	-	GARL or G
Potatoes	-	POT or P
Wheat	-	WHEA or W

The second part of the name is a one digit number indicating the technology class. The third part is a one digit number and indicates the number of the activity within the technology class. Thus, CORN42 or C42 refers to corn-technology 4, number 2.

Crop	Technology class	Number
Bean	1	1
Bean	1	2
Bean	2	1

Crop	Technology class	Number
Corn	1	1
Corn	1	2
Corn	1	3
Corn	2	1
Corn	2	2
Corn	2	3
Corn	2	4
Corn	4	1
Corn	4	2
Corn	4	3
CN/BN	1	1
CN/BN	1	2
CN/BN	2	1
CN/BN	2	2
CN/BN	2	3
Potato	1	1
Potato	2	1
Potato	2	2
Potato	2	3
Wheat	1	1
Wheat	2	1
Wheat	2	2
Wheat	2	3
Wheat	2	4
Wheat	4	1
Wheat	4	2
Wheat	4	3
Wheat	4	4

APPENDIX B-2

Table 2B-1 contains the cost and income factors used in the crop insurance model. All of the numbers come from the House model except where indicated.

Column 1 represents the cost of nonlabor crop inputs (e.g., fertilizer, machinery).

Column 2 represents the cost of labor. It includes farmer, family and hired labor. The costs of farmer and family labor represent shadow prices rather than an actual wage rate.

Column 3 represents the cost of credit. In the House model, credit requirements are determined on the basis of total working capital costs plus consumption. In order to assign costs on a crop activity basis a credit cost has been estimated based on 8 percent of total material and labor input costs for all crops except garlic (2 percent) and potatoes (6 percent). The different rates relate to the different harvest periods.

Column 4 represents total product cost. In the crop insurance model it is used as the measure of working capital requirements.

Column 5 is the selling price of each crop activity's production in kilograms. In the case of interplanted corn/bean, the selling price is that of corn.

Column 6 is the expected yield. In the case of interplanted corn/bean activities, a corn yield equivalence is used instead of separate corn and bean yields.

Column 7 is column 5 multiplied by column 6 and represents expected income.

Column 8 is column 7 minus column 4 and represents expected net return.

Column 9 is column 8 divided by column 4 and represents the expected return on cost.

Column 10 is the worst expected yield and is derived from the frequency distribution tables rather than the House model data.

Column 11 is the measure of cost activity risk computed by dividing column 10 by column 7.

Table 2B-1. Cost and Income Data Used in the Crop Insurance Model

Crop activity	Costs: Material inputs (quetzales) (1)	Costs: Labor inputs (quetzales) (2)	Costs: Credit charges (quetzales) (3)	Costs: Total (quetzales) (4)	Selling price (quetzales per kilogram) (5)	Mean expected yield (kilograms per hectare) (6)	Expected income (quetzales) (7)	Net return (quetzales) (8)	Return on cost (9)	Worst expected income (quetzales) (10)	Ratio--worst to mean income (11)
Bean -- 11	11.5	11.3	1.8	24.6	.287	103.4	29.7	5.1	.21	7.4	.25
-- 12	23.1	37.4	4.8	65.3	.287	425.9	122.2	56.9	.87	30.6	.25
-- 21	72.6	31.2	8.3	112.1	.287	718.7	206.3	94.2	.84	51.6	.25
Corn -- 11	13.9	43.1	4.6	61.6	.122	843.7	102.9	41.3	.67	20.6	.20
-- 12	22.7	57.9	6.5	87.1	.122	1,192.8	145.5	58.4	.67	29.1	.20
-- 13	22.6	105.2	10.1	137.9	.122	1,787.5	218.1	80.2	.58	43.6	.20
-- 21	53.9	50.8	8.3	113.0	.122	1,552.3	189.4	76.4	.68	56.8	.30
-- 22	58.3	49.5	8.6	116.4	.122	1,733.8	211.5	94.7	.81	63.5	.30
-- 23	93.4	44.9	12.5	150.8	.122	2,373.1	289.5	138.7	.92	86.9	.30
-- 24	92.3	45.8	11.1	149.2	.122	1,646.0	200.8	51.6	.35	60.2	.30
-- 41	75.3	34.1	8.8	118.2	.122	1,603.9	195.7	77.5	.66	31.3	.16
-- 42	101.9	58.3	12.7	172.9	.122	3,505.9	427.7	254.8	1.47	68.4	.16
-- 43	169.6	32.8	16.2	218.6	.122	2,338.2	285.3	66.7	.31	45.6	.16
CN/BN -- 11	11.6	31.1	3.4	46.1	.122	3,310.7	403.9	357.8	7.76	80.8	.20
-- 12	7.9	17.0	2.0	26.9	.122	1,263.9	154.2	127.3	4.73	30.8	.20
-- 21	60.8	38.8	8.0	107.6	.122	3,168.0	386.5	278.9	2.59	77.3	.30
-- 22	51.2	63.1	9.1	123.4	.122	1,271.3	155.1	31.7	.26	31.0	.30
-- 23	63.7	44.8	8.6	117.1	.122	1,904.9	232.4	115.3	.98	46.5	.30
Garlic -- 21	261.8	105.5	7.4	274.7	.3805	4,886.4	1,859.3	1,485.0	3.96	297.5	.16
-- 22	352.6	245.3	12.0	609.9	.3805	5,601.3	2,131.3	1,521.4	2.49	341.0	.16
Potatoes -- 11	303.9	39.4	20.5	363.8	.179	7,033.1	1,258.9	895.1	2.46	944.2	.75
-- 21	358.9	87.1	26.7	472.7	.179	7,966.1	1,458.9	986.2	2.09	1,094.2	.75
-- 22	840.8	139.3	58.7	1,038.8	.179	21,849.7	3,911.1	2,872.3	2.77	2,933.3	.75
-- 23	379.0	128.6	30.5	538.1	.179	9,576.5	1,714.2	1,176.1	2.19	1,285.7	.75
Wheat -- 11	55.8	53.7	8.8	118.3	.177	1,156.6	204.7	86.4	.73	98.3	.48
-- 21	92.7	51.7	11.6	156.0	.177	1,186.2	210.0	54.0	.35	100.8	.48
-- 22	164.3	57.2	17.7	239.2	.177	1,732.5	306.7	67.5	.28	147.2	.48
-- 23	114.7	31.5	11.7	157.9	.177	2,282.4	404.0	246.1	1.56	193.9	.48
-- 24	88.0	50.0	11.0	149.0	.177	1,442.9	255.4	106.4	.71	122.6	.48
-- 41	123.3	46.7	13.7	183.7	.177	1,308.3	231.6	47.9	.26	90.3	.39
-- 42	115.6	52.9	13.5	182.0	.177	1,760.9	311.7	129.7	.71	121.6	.39
-- 43	106.2	31.6	11.1	148.9	.177	1,706.1	302.0	195.7	1.84	117.8	.39
-- 44	77.9	43.5	9.7	131.1	.177	1,367.7	242.1	111.0	.85	94.4	.39

APPENDIX B-3

Appendix B-3 contains the yield distribution tables used to generate the actual yields and the worst yield. Table 3B-1 indicates the specific yield distribution applied to each crop activity. Tables 3B-2 through 3B-9 contain the set yield distributions which were derived from the Guatemala and Colombia small farm data surveys.

Figures 3B-1 and 3B-2 are presented as examples of the curves derived from the yield distribution tables. Figure 3B-1 represents the plot of columns 3 and 4 from the yield distribution table for corn-technology 4. Figure 3B-2 represents the cumulative frequency distribution of the previous curve.

The worst yield can be seen on the cumulative frequency distribution curve as the yield which has a cumulative frequency of 10 percent.

The actuarial cost of insurance can also be seen on the cumulative frequency distribution as the frequency corresponding to the level of coverage.

Table 3B-1. List of Yield Distributions Used for Each Crop Activity

Crop activity	Yield distribution
Bean-11	Beans-Technology 2
-12	"
-21	"
Corn-11	Corn-Technology 1
-12	"
-13	"
-21	Corn-Technology 2
-22	"
-23	"
-24	"
-41	Corn-Technology 4
-42	"
-43	"
CN/BN-11	Corn-Technology 1
-12	"
-21	Corn-Technology 2
-22	"
-23	"
Garlic-21	Tomato-Technology 3
-22	"
Potato-11	Potato-Technology 1 (Colombia)
-21	"
-22	"
-23	"
Wheat-11	Wheat-Technology 3
-21	"
-22	"
-23	"
-24	"
-41	Wheat-Technology 4
-42	"
-43	"
-44	"

Table 3B-2. Yield Distribution -- Bean -- Technology 2
(All Regions, Guatemala)

Yield range (kilograms per hectare)	Midpoint of yield range (kilograms per hectare)	Midpoint yield in relation to mean (percent)	Frequency of occurrence (percent)	Range based on frequency
0-80	40	5	0	0-0.9[a]
81-160	120	16	2	1-2.9
161-240	200	27	9	3-11.9
241-320	280	38	3	12-14.9
321-400	360	48	9	15-23.9
401-480	440	59	2	24-25.9
481-560	520	70	10	26-35.9
561-640	600	80	7	36-42.9
641-720	680	91	10	43-52.9
721-800	760	102	5	53-57.9
801-880	840	113	3	58-60.9
881-960	920	123	3	61-63.9
961-1040	1000	134	16	64-79.9
1041-1120	1080	145	5	80-84.9
1121-1200	1160	155	3	85-87.9
1201-1280	1240	166	5	88-92.9
1281-1360	1320	177	2	93-94.9
1361-1440	1400	188	0	95-95.9[a]
1441-1520	1480	198	3	96-97.9[a]
1521-1600	1560	209	0	98-98.9[a]
1601-1680	1640	220	2	99-99.9[a]

Note: Total number of observations: 58
Mean yield of distribution: 746.1
a. Adjustment to range to maintain consistency.
Source: Guatemala Small Farm Survey, 1973.

Table 3B-3. Yield Distribution -- Corn -- Technology 1
(All Regions, Guatemala)

Yield range (kilograms per hectare)	Midpoint of yield range (kilograms per hectare)	Midpoint yield in relation to mean (percent)	Frequency of occurrence (percent)	Range based on frequency
0-270	135	12	4	0-3.9
271-540	405	35	17	4-20.9
541-810	675	58	16	21-36.9
811-1080	945	81	17	37-53.9
1081-1350	1215	104	16	54-69.9
1351-1620	1485	128	10	70-79.9
1621-1890	1755	151	4	80-83.9
1891-2160	2025	174	8	84-91.9
2161-2430	2295	197	1	92-92.9
2431-2700	2565	221	4	93-96.9
2701-2970	2835	244	0	97-97.9[a]
2971-3240	3105	267	1	98-98.9
3241-3510	3375	290	1	99-99.9

Note: Total number of observations: 289
Mean yield of distribution: 1162.5
a. Adjustment to range to maintain consistency.
Source: Guatemala Small Farm Survey, 1973.

Table 3B-4. Yield Distribution -- Corn -- Technology 2
(All Regions, Guatemala)

Yield range (kilograms per hectare)	Midpoint of yield range (kilograms per hectare)	Midpoint yield in relation to mean (percent)	Frequency of occurrence (percent)	Range based on frequency
0-250	125	8	0	0-0.9[a]
251-500	375	24	6	1-6.9
501-750	625	40	8	7-14.9
751-1000	875	54	8	15-22.9
1001-1250	1125	72	16	23-38.9
1251-1500	1375	88	16	39-54.9
1501-1750	1625	104	12	55-66.9
1751-2000	1875	120	8	67-74.9
2001-2250	2125	136	10	75-84.9
2251-2500	2375	152	4	85-88.9
2501-2750	2625	168	4	89-92.9
2751-3000	2875	184	2	93-94.9
3001-3250	3125	200	4	95-98.9
3251-3500	3375	216	1	99-99.9

Note: Total number of observations: 254
Mean yield of distribution: 1564.4
a. Adjustment to range to maintain consistency.
Source: Guatemala Small Farm Survey, 1973.

Table 3B-5. Yield Distribution -- Corn -- Technology 4
(All Regions, Guatemala)

Yield range (kilograms per hectare)	Midpoint of yield range (kilograms per hectare)	Midpoint yield in relation to mean (percent)	Frequency of occurrence (percent)	Range based on frequency
0-650	325	13	8	0-7.9
651-1300	975	40	14	8-21.9
1301-1950	1625	66	19	22-40.9
1951-2600	2275	93	24	41-64.9
2601-3250	2925	120	14	65-78.9
3251-3900	3575	146	12	79-90.9
3901-4550	4225	173	3	91-93.9
4551-5200	4875	199	3	94-96.9
5201-5850	5525	226	1	97-97.9
5851-6400	6175	253	0	98-98.9[a]
6401-7050	6725	275	1	99-99.9

Note: Total number of observations: 139
Mean yield of distribution: 2443.6
a. Adjustment to range to maintain consistency.
Source: Guatemala Small Farm Survey, 1973.

Table 3B-6. Yield Distribution -- Tomato -- Technology 3
(Region 5, Guatemala)

Yield range (kilograms per hectare)	Midpoint of yield range (kilograms per hectare)	Midpoint yield in relation to mean (percent)	Frequency of occurrence (percent)	Range based on frequency
0-2000	1000	9	6	0-5.9
2001-4000	3000	26	10	6-15.9
4001-6000	5000	43	13	16-28.9
6001-8000	7000	60	13	29-41.9
8001-10000	9000	77	10	42-51.9
10001-12000	11000	94	16	52-67.9
12001-14000	13000	111	3	68-70.9
14001-16000	15000	128	3	71-73.9
16001-18000	17000	145	6	74-79.9
18001-20000	19000	163	0	80-84.9[a]
20001-22000	21000	180	3	85-87.9
22001-24000	23000	197	3	88-90.9
24001-26000	25000	214	6	91-96.9
26001-28000	27000	231	3	98-99.9

Note: Total number of observations: 31
Mean Yield of distribution: 11685
a. Adjustment to range to maintain consistency.
Source: Guatemala Small Farm Survey, 1973.

Table 3B-7. Yield Distribution -- Potato -- Technology 1 (Colombia)

Yield range (kilograms per hectare)	Midpoint of yield range[a] (kilograms per hectare)	Midpoint yield in relation to mean (percent)	Frequency of occurrence (percent)	Range based on frequency
	1800	17	1	0-0.9
	2500	24	1	1-1.9
	2600	25	1	2-2.9
	4000	38	1	3-3.9
	5000	48	1	4-4.9
	6000	57	1	5-5.9
	7000	67	2	6-7.9
	7500	72	1	8-8.9
	7812	75	1	9-9.9
	8000	76	6	10-15.9
	9000	86	7	16-22.9
	9375	89	9	23-31.9
	9500	91	1	32-37.9[b]
	10000	95	16	38-43.9[b]
	10100	96	1	44-49.9[b]
	10200	97	1	50-54.9[b]
	10500	100	4	55-58.9
	11000	105	4	59-62.9
	12000	115	22	63-84.9
	12300	117	1	85-85.9
	13000	124	2	86-87.9
	13750	131	1	88-88.9
	14000	134	2	89-90.9
	15000	143	5	91-95.9
	16000	153	2	96-97.9
	18000	172	2	98-99.9

Note: Total number of observations: 85
Mean yield of distribution: 10447

a. Actual yield

b. Adjustment to range to maintain consistency.

Source: INCORA Data Survey, Colombia, 1969.

Table 3B-8. Yield Distribution -- Wheat -- Technology 3
(Region 1, Guatemala)

Yield range (kilograms per hectare)	Midpoint of yield range (kilograms per hectare)	Midpoint yield in relation to mean (percent)	Frequency of occurrence (percent)	Range based on frequency
0-120	60	5	1	0-0.9
121-240	180	14	0	1-1.9[a]
241-360	300	23	0	2-2.9[a]
361-480	420	32	4	3-4.9[a]
481-600	540	42	3	5-7.9
601-720	660	51	4	8-11.9
721-840	780	60	3	12-14.9
841-960	900	69	10	15-24.9
961-1080	1020	79	13	25-37.9
1081-1200	1140	88	6	38-43.9
1201-1320	1260	97	16	44-59.9
1321-1440	1380	106	3	60-62.9
1441-1560	1500	116	6	63-68.9
1561-1680	1620	125	7	69-75.9
1681-1800	1740	134	4	76-79.9
1801-1920	1860	144	7	80-86.9
1921-2040	1980	153	4	87-90.9
2041-2160	2100	162	3	91-93.9
2161-2280	2220	171	4	94-97.9
2281-2400	2340	181	0	98-98.9[a]
2401-2520	2460	190	1	99-99.9

Note: Total number of observations: 70
Mean yield of distribution: 1295.9
a. Adjustment to range to maintain consistency.
Source: Guatemala Small Farm Survey, 1973.

Table 3B-9. Yield Distribution -- Wheat -- Technology 4
(Region 1, Guatemala)

Yield range (kilograms per hectare)	Midpoint of yield range (kilograms per hectare)	Midpoint yield in relation to mean (percent)	Frequency of occurrence (percent)	Range based on frequency
0-180	90	6	1	0-0.9
181-360	270	18	2	1-2.9
361-540	450	31	2	3-4.9
541-720	630	43	8	5-12.9
721-900	810	55	5	13-17.9
901-1080	990	67	12	18-22.9[a]
1081-1160	1170	79	0	23-29.9[a]
1161-1340	1250	85	9	30-38.9
1341-1520	1430	97	7	39-45.9
1521-1700	1610	109	18	46-63.9
1701-1880	1790	122	13	64-76.9
1881-2060	1970	134	7	77-83.9
2061-2240	2150	146	10	84-93.9
2241-2420	2330	158	0	94-94.9[a]
2421-2600	2510	170	1	95-95.9
2601-2780	2690	183	2	96-96.9[a]
2781-2960	2870	195	1	97-97.9
2961-3140	3050	207	0	98-98.9[a]
3141-3320	3230	219	1	99-99.9

Note: Total number of observations: 110
Mean yield of distribution: 1472.7
a. Adjustment to range to maintain consistency.
Source: Guatemala Small Farm Survey, 1973.

FIGURE 3B-1
YIELD DISTRIBUTION, CORN--TECHNOLOGY 4

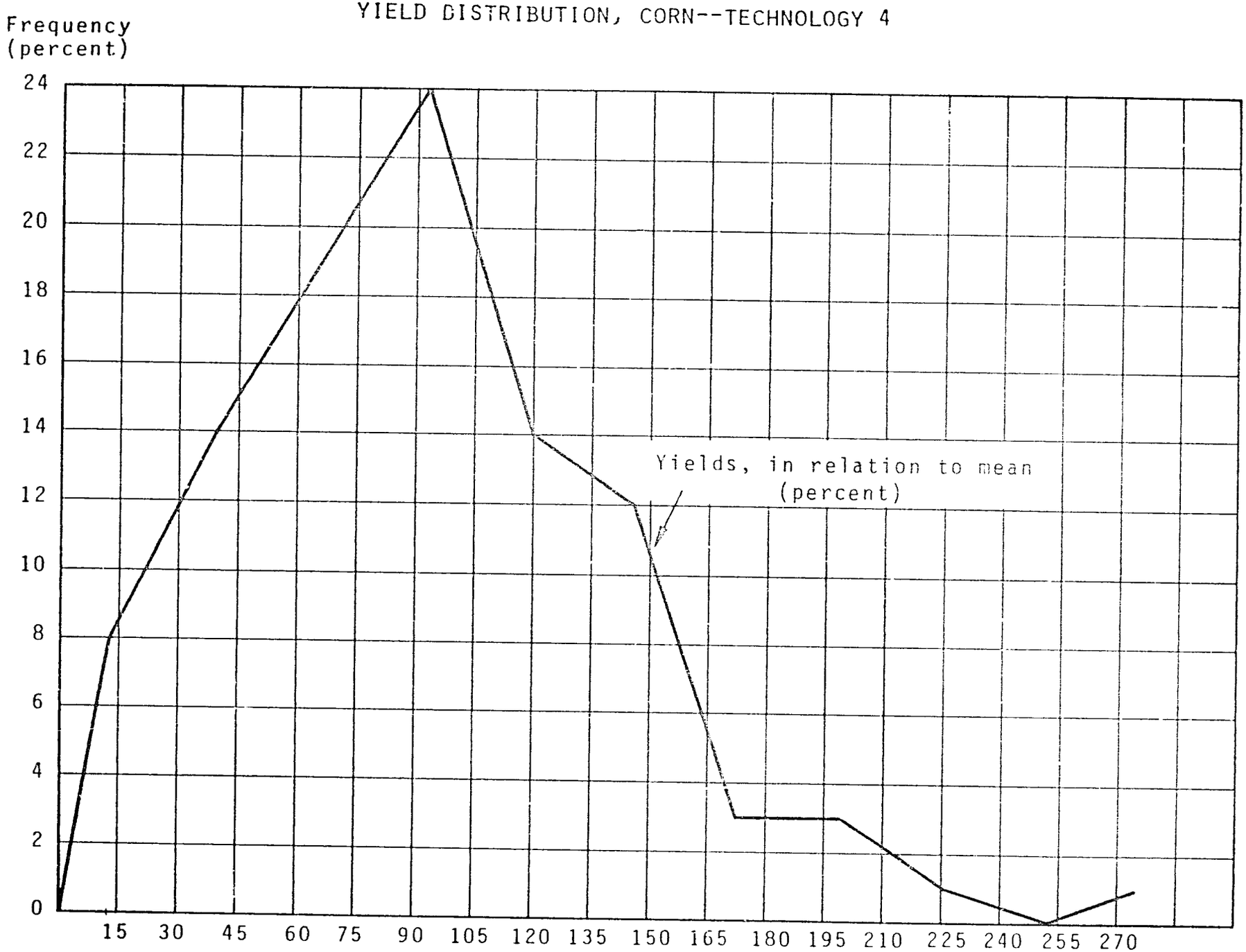
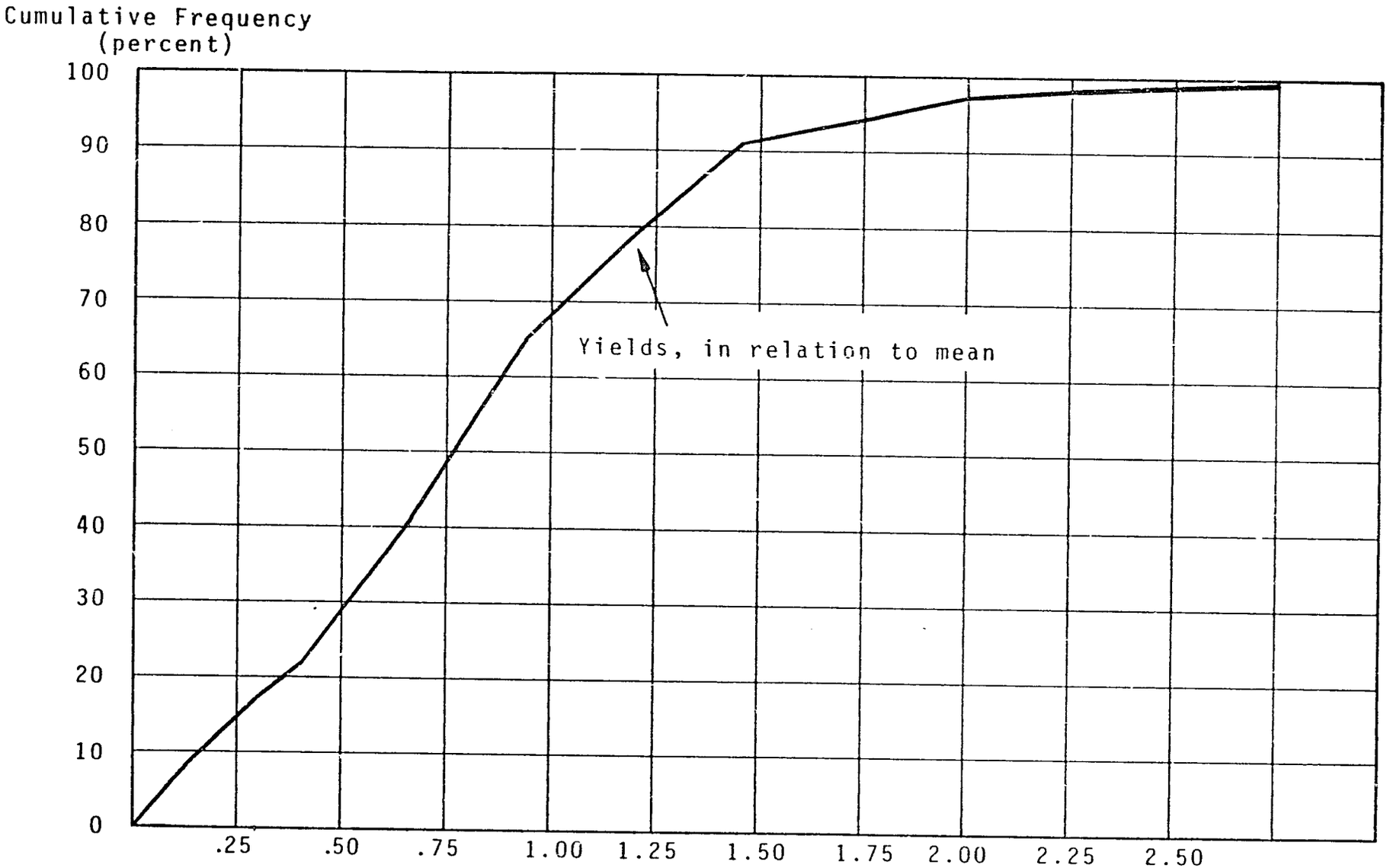


FIGURE 3B-2

CUMULATIVE FREQUENCY DISTRIBUTION FOR CORN--TECHNOLOGY 4



APPENDIX B-4

This appendix contains the results of the sensitivity analysis. The sensitivity tests are identified by the following names:

BASE - the control solution used in the analysis

A1 -- same as BASE except credit limit reduced by -Q50
A2 -- " " " " -Q100
A3 -- " " " " -Q150
A4 -- " " " " -Q200

B1 -- same as BASE except risk aversion level reduced by -.02
B2 -- " " " " -.04
B3 -- " " " " -.06
B4 -- " " " " -.08
B5 -- " " " " -.10

C1 -- same as BASE except working capital limit reduced by -Q25
C2 -- " " " " " " -Q50
C3 -- " " " " " " -Q75
C4 -- " " " " " " -Q100

-- POT -- indicates potatoes are in the crop mix

-- 40 percent -- indicates insurance coverage at 40 percent of mean yield

-- 30 percent -- indicates insurance coverage at 30 percent of mean yield

All tests are separated into two cases, without insurance and with insurance. All results are for a single farming unit of 1-3 hectares.

The first set of tables 4B-1 through 4B-4 summarize the results of the LP optimization phase in which the crop mix is determined. For each crop activity in the mix, the hectares in production are given. The sum of the hectares plus land rented out is 1.8 hectares.

The column labeled parameter gives the name, value, and incremental change in the parameter value relative to the base condition specified as the first solution. CR refers to the credit availability rows. RA refers to the risk aversion rows and WC refers to the working capital rows. IC refers to a change of coverage level which requires an adjustment in some of the technical coefficients.

The column labeled net income gives the expected value of net income as computed in the LP optimization phase and the incremental change which results from the change in the parameter value.

The last column gives the rate of return of net income relative to the rate of return of the parameter.

Tables 4B-5 and 4B-6 give the stream of net income for each of the sensitivity runs including the base solutions.

ROWS

Abbreviations	Definitions
OUT	Crop activities excluded from consideration
MCST	Production cost for without insurance case
MICST	Production cost for with insurance case
MINC	Worst expected income
INCOME	Mean expected income
INSUR	Insurance cost
INCDROP	Difference between mean and worst income
MAXCOST	Maximum cost upper limit
COST	Change in cost limit

COLUMNS

MINCI	Total worst income for all crops in solution
INCI	Total insurance cost for all crops in solution
GINC	Total income for all crops in solution
COSTI	Total cost for all crops in solution
COSTMAX	Maximum cost (MAXCOST - COST)

Table 4B-1. Sensitivity Analysis--without Insurance

Solution	Crop activities (hectares)	Land rented out	Parameter			Net income		Percent change in net income/ percent change in parameter
			Name	Value	Percent change in relation to Base	Value	Percent change in relation to Base	
Base	C23 (.52) N23 (.18) W11 (.45)	(.49)	n.a.	n.a.	n.a.	168	0	n.a.
A1	C23 (.52) N23 (.18) G21 (.01) W11 (.45)	(.65)	CR	Q250	-16.7	161	-4.2	.251
A2	C23 (.3) N23 (.18) G21 (.02) W11 (.45)	(.85)	CR	Q200	-16.7	152	-5.3	.317
B1	C23 (.77) N23 (.18) G21 (.02) W11 (.45)	(.38)	RA	33%	-5.7	205	22.0	-3.86
B2	C23 (.69) C42 (.05) N23 (.18) G21 (.04) W11 (.45)	(.4)	RA	31%	-5.7	233	16.7	-2.93
B3	C42 (.19) N23 (.85) G21 (.03) G22 (.00) W11 (.45)	(.27)	RA	29%	-5.7	246	7.7	-1.35
B4	C42 (.32) N23 (.60) G21 (.00) G22 (.03) W11 (.45)	(.4)	RA	27%	-5.7	255	5.4	-0.947
B5	C42 (.47) N23 (.32) G22 (.04) W11 (.45)	(.53)	RA	25%	-5.7	263	4.8	-0.842
C1	C23 (.67) N23 (.18) G21 (.00) W11 (.45)	(.5)	WC	Q150	-12.5	167	-0.6	.048
C2	C23 (.48) N23 (.18) G21 (.01) W11 (.45)	(.68)	WC	Q125	-12.5	160	-4.2	.336
C3	C23 (.3) N23 (.18) G21 (.02) W11 (.45)	(.86)	WC	Q100	-12.5	152	-4.7	.376
C4	N23 (.36) G21 (.02) W11 (.43)	(.99)	WC	Q75	-12.5	141	-6.6	.528

Table 4B-2. Sensitivity Analysis--without Insurance (with Potatoes)

Solution	Crop activities (hectares)					Land rented out	Parameter			Net income		Percent change in net income/ percent change in parameter
							Name	Value	Percent change in relation to Base	Value	Percent change in relation to Base	
Base --Potatoes	C12 (.18)	N23 (.18)	G22 (.04)	P22 (.09)	W11 (.07)	(1.24)	n.a.	n.a.	n.a.	402	n.a.	n.a.
C1--Potatoes	C12 (.18)	N23 (.18)	G22 (.04)	P22 (.09)	W11 (.07)	(1.24)	WC	Q150	-12.5	402	0	0
C2--Potatoes	C12 (.18)	N23 (.18)	G21 (.04)	P22 (.09)	W11 (.07)	(1.24)	WC	Q125	-12.5	381	-5.2	0.416
C3--Potatoes	C12 (.18)	N23 (.18)	G21 (.04)	P22 (.06)	W11 (.07)	(1.27)	WC	Q100	-12.5	314	-16.7	1.336
C4--Potatoes	C12 (.18)	N23 (.18)	G21 (.04)	P22 (.04)	W11 (.07)	(1.29)	WC	Q75	-12.5	247	-16.7	1.336

n.a. = not applicable

Table 4B-3. Sensitivity Analysis--with Insurance

Solution	Crop activities (hectares)				Land rented out	Parameter			Net income		Percent change in net income/ percent change in parameter
						Name	Value	Percent change in relation to Base	Value	Percent change in relation to Base	
Base	B12 (.18)	C42 (1.44)	G22 (.04)	W11 (.07)	(.07)	n.a.	n.a.	n.a.	431	0	n.a.
A1	B12 (.18)	C42 (1.28)	G22 (.04)	W11 (.07)	(.23)	CR	Q474	-9.5	398	-7.7	.811
A2	B12 (.18)	C42 (1.13)	G22 (.04)	W11 (.07)	(.38)	CR	Q424	-9.5	365	-7.6	.80
A3	B12 (.18)	C42 (.98)	G22 (.04)	W11 (.07)	(.54)	CR	Q374	-9.5	332	-7.7	.811
A4	B12 (.18)	C42 (.82)	G22 (.04)	W11 (.07)	(.69)	CR	Q324	-9.5	299	-7.6	.80
B1 thru B5	B12 (.18)	C42 (1.44)	G22 (.04)	W11 (.07)	(.07)	RA	33/25%	-5.7	431	0	0
C1	B12 (.18)	C42 (1.40)	G21 (.04)	W44 (.07)	(.12)	WC	Q325	-7.1	422	-2.1	.296
C2	B12 (.18)	C42 (1.27)	G21 (.04)	W44 (.07)	(.24)	WC	Q300	-7.1	395	-6.3	.887
C3	B12 (.18)	C42 (1.15)	G21 (.04)	W44 (.07)	(.36)	WC	Q275	-7.1	369	-6.0	.845
C4	B12 (.18)	C42 (1.03)	G21 (.04)	W44 (.07)	(.48)	WC	Q250	-7.1	343	-6.0	.845
Base-40%	B12 (.18)	C42 (1.44)	G22 (.04)	W11 (.07)	(.07)	IC	40%	-25.0	431	0	0
Base-30%	C42 (.31)	N23 (.18)	G21 (.04)	W11 (.45)	(.83)	IC	30%	-15.0	217	-49.7	3.31

n.a. = not applicable

Table 4B-4. Sensitivity Analysis--with Insurance (with Potatoes)

Solution	Crop activities (hectares)	Land rented out	Parameter			Net income		Percent change in net income/ percent change in parameter
			Name	Value	Percent change in relation to Base	Value	Percent change in relation to Base	
Base	B12 (.18) C42 (.44) G22 (.04) P22 (.14) W11 (.07)	(.92)	n.a.	n.a.	n.a.	621	0	n.a.
C1	B12 (.18) C42 (.44) G22 (.04) P22 (.14) W11 (.07)	(.92)	WC	Q325	-7.1	621	0	0
C2	B12 (.18) C42 (.44) G22 (.04) P22 (.14) W11 (.07)	(.92)	WC	Q300	-7.1	621	0	0
C3	B12 (.18) C42 (.42) G21 (.04) P22 (.14) W11 (.07) W44 (.95)	(.95)	WC	Q275	-7.1	615	-1.0	0.14
C4	B12 (.08) C42 (.26) N23 (.10) G21 (.04) P22 (.14) W44 (.07)	(1.10)	WC	Q250	-7.1	587	-4.5	0.63

n.a. = not applicable

Table 4B-5. Sensitivity Analysis -- with 30 Percent Insurance (with Potatoes)

Solution	Crop activities (hectares)				Land rented out	Parameter			Net income		Percent change in net income/ percent change in parameter
						Name	Value (percent)	Percent change in relation to Base	Value	Percent change in relation to Base	
Base--Potatoes	C42 (.31)	N23 (.18)	G21 (.04)	W11 (.45)	(.83)	n.a.	n.a.	n.a.	217	0	n.a.
B1	C42 (.82)	N23 (.18)	G21 (.04)	W11 (.45)	(.31)	RA	33%	-5.7	328	51.2	-8.98
B2	C42 (1.33)	N23 (.18)	G22 (.04)	W11 (.45)	(.06)	RA	31%	-5.7	425	44.7	7.84
B3	B12 (.18)	C42 (1.44)	G22 (.04)	W11 (.07)	(.07)	RA	29%	-5.7	431	2.7	0.47

n.a. = not applicable

Table 4B-6. Stream of Net Income without Insurance for Various Solutions

Solution	1	2	3	4	5	6	7	8	9	10	Total
Base	205	264	212	196	282	8	59	-18	242	85	1,534
A1	187	206	198	177	244	23	56	-5	219	84	1,391
A2	164	132	181	154	195	43	53	12	188	84	1,205
B1	237	288	306	277	310	31	55	-1	334	115	1,952
B2	260	280	377	337	315	57	51	20	395	140	2,232
B3	288	295	408	368	328	65	52	27	420	150	2,401
B4	301	280	428	386	320	71	44	32	429	152	2,444
B5	315	267	438	396	312	78	40	39	429	153	2,467
C1	203	258	211	194	278	10	58	-17	240	85	1,519
C2	183	194	196	174	236	27	56	-2	214	84	1,361
C3	163	131	180	154	194	43	53	12	187	84	1,203
C4	141	80	160	132	155	53	49	22	160	80	1,034
C1--Pot	347	484	281	507	396	267	315	310	478	230	3,614
C2--Pot	329	461	262	473	377	251	299	290	447	218	3,475
C3--Pot	260	352	242	390	294	192	214	216	378	175	2,712
C4--Pot	191	242	222	306	211	133	129	143	308	132	2,017

Table 4B-7. Stream of Net Income with Insurance for Various Solutions

Solution	1	2	3	4	5	6	7	8	9	10	Total
Base	510	619	743	743	461	69	48	45	750	179	4,169
A1	462	555	679	679	413	68	46	44	686	167	3,799
A2	415	490	614	614	366	66	45	42	621	155	3,429
A3	367	426	550	549	318	65	43	41	557	143	3,060
A4	320	361	485	485	271	63	42	39	492	131	2,690
C1	502	606	713	714	455	73	55	47	719	180	4,065
C2	464	555	661	663	418	72	54	46	667	170	3,770
C3	426	503	610	611	380	70	53	45	616	161	3,475
C4	388	452	558	560	342	69	51	44	564	151	3,179
C1-Pot	616	858	447	824	652	411	547	477	747	358	5,936
C3-Pot	613	851	422	802	651	415	554	479	721	359	5,867
C4-Pot	564	808	382	746	625	409	545	477	673	342	5,569
Base--40 percent	530	632	763	763	476	28	-1	4	771	199	4,164
Base--30 percent	238	174	320	280	229	75	55	37	307	122	1,838
B1--30 percent	409	402	547	508	399	68	48	31	535	173	3,121
B2--30 percent	530	627	779	745	517	42	6	17	769	203	4,235
B3--30 percent	543	638	777	776	489	41	4	17	784	213	4,282

APPENDIX B-5

This appendix contains the results of the internal rate of return (IRR) calculations used in the cost-benefit analysis.

Each of the IRR calculations is done for a proposed situation (some form of insurance) in relation to an existing situation (no insurance). The insurance case is designated by a "W" preceding the model solution used, while the without insurance case is preceded by a "W/O."

The first IRR calculation in each table contains the two base cases (with and without insurance) throughout the analysis of Section III. The succeeding IRR calculations contain variants of one or both of the base cases. All cases are described in detail in Appendix B-4.

Table 5B-1. Effect of Assumption on Insurance Coverage on the Internal Rate of Return[a]

(Quetzales)

Year	W: Base (50% coverage) W/o: Base			W: Base (40% coverage) W/o: Base			W: Base (30% coverage) W/o: Base		
	Total Cost[b]	Total benefit[c]	Net benefit	Total cost[b]	Total benefit[c]	Net benefit	Total cost[b]	Total benefit[c]	Net benefit
0	50	n.a.	-50	50	n.a.	-50	50	n.a.	-50
1	160	76	-84	160	81	-79	160	8	-152
2	275	355	80	275	368	93	275	-90	-365
3	350	1,328	975	350	1,378	1,028	350	270	-80
4	370	1,915	1,545	370	1,984	1,614	370	294	-76
5	380	895	515	380	970	590	380	-265	-645
6	390	458	68	390	150	-240	390	502	112
7	400	-105	-505	400	-570	-970	400	-38	-438
8	410	756	346	410	264	-146	410	660	250
9	420	7,366	6,946	420	7,670	7,250	420	942	522
10	430	1,598	1,168	430	1,938	1,508	430	629	199
IRR:	--------184 percent---------			--------192 percent---------			------- -12 percent---------		

n.a. = not applicable

a. Insurance coverage is defined as a percentage of the mean expected yield of the insured crop activities.

b. For a discussion of cost data refer to Section

c. Total benefit is computed as the stream of net income with insurance (W) minus without insurance (w/o). Sources of data are tables

Table 5B-2. Effect of Assumption on Insurance Program Administrative Costs on the Internal Rates of Return (IRR)

(Quetzales)

	W: Base (50% coverage) W/o: Base			Cost (2) W: Base (50% coverage) W/o: Base			Cost (3) W: Base (50% coverage) W/o: Base		
Year	Total cost[b]	Total benefit[c]	Net benefit	Total cost[b]	Total benefit[c]	Net benefit	Total cost[b]	Total benefit[c]	Net benefit
0	50	n.a.	-50	150	n.a.	-150	250	n.a.	-250
1	160	76	-84	200	76	-124	240	76	-164
2	275	355	80	344	355	11	413	355	-58
3	350	1,328	975	438	1,328	890	525	1,328	803
4	370	1,915	1,545	463	1,915	1,452	555	1,915	1,360
5	380	895	515	475	895	420	570	895	325
6	390	458	68	488	458	-30	585	458	-127
7	400	-105	-505	500	-105	-605	600	-105	-705
8	410	756	346	513	756	243	615	756	141
9	420	7,366	6,946	525	7,366	6,841	630	7,366	6,736
10	430	1,598	1,168	538	1,598	1,060	645	1,598	953
IRR:	---------184 percent--------			---------104 percent---------			----------73 percent--------		

n.a. = not applicable

a. Administrative costs were changed in relation to the first case as follows:
Cost (2): Startup cost +Q100; annual cost +125%
Cost (3): Startup cost +Q200; annual cost +150%

b. For a discussion of cost data refer to Section

c. Total benefit is computed as the stream of net income with insurance (W) minus without insurance (w/o). Source of data is table

Table 5B-3. Effect of Assumption on Farmer's Risk Aversion on the Internal Rate of Return (IRR)

(Quetzales)

	W: Base (50% coverage) W/o: Base			W: B1 (50% coverage) W/o: B1			W: B3 (50% coverage) W/o: B3			W: B5 (50% coverage) W/o: B5		
Year	Total cost[b]	Total benefit[c]	Net benefit	Total cost[b]	Total benefit[c]	Net benefit	Total cost[b]	Total benefit[c]	Net benefit	Total cost[b]	Total benefit[c]	Net benefit
0	50	n.a.	-50	50	n.a.	-50	50	n.a.	-50	50	n.a.	-50
1	160	76	-84	160	68	-92	160	56	-104	160	49	-111
2	275	355	80	275	331	56	275	324	49	275	352	77
3	350	1,328	975	350	1,092	742	350	838	488	350	762	412
4	370	1,915	1,545	370	1,631	1,261	370	1,312	942	370	1,214	844
5	380	895	515	380	755	375	380	665	285	380	745	365
6	390	458	68	390	285	-105	390	30	-360	390	-68	-458
7	400	-105	-505	400	-66	-466	400	-38	-438	400	76	-324
8	410	756	346	410	552	142	410	216	-194	410	72	-338
9	420	7,366	6,946	420	6,032	5,612	420	4,785	4,365	420	4,654	4,234
10	430	1,598	1,168	430	1,088	658	430	493	63	430	442	12
IRR:	------184 percent-------			------156 percent------			------122 percent-------			-------116 percent------		

n.a. = not applicable

a. Risk aversion for cases B1, B3, and B5 were reduced relative to the base case by 2 percent, 6 percent, and 10 percent, respectively.

b. For a discussion of cost data refer to Section

c. Total benefit is computed as the stream of net income with insurance (W) minus without insurance (w/o). Sources of data are tables

Table 5B-4. Effect of Assumption on Credit Availability on the Internal Rate of Return[a]

(Quetzales)

	W: Base (50% coverage) W/o: Base			W: A1 (50% coverage) W/o: Base			W: A4 (50% coverage) W/o: Base		
Year	Total cost[b]	Total benefit[c]	Net benefit	Total cost[b]	Total benefit[c]	Net benefit	Total cost[b]	Total benefit[c]	Net benefit
0	50	n.a.	-50	50	n.a.	-50	50	n.a.	-50
1	160	76	-84	160	64	-96	160	29	-131
2	275	355	80	275	291	16	275	97	-178
3	350	1,328	975	350	1,168	818	350	682	332
4	370	1,915	1,545	370	1,690	1,320	370	1,012	642
5	380	895	515	380	655	275	380	-55	-435
6	390	458	68	390	450	60	390	412	22
7	400	-105	-505	400	-124	-524	400	-162	-562
8	410	756	346	410	744	334	410	684	274
9	420	7,366	6,946	420	6,438	6,018	420	3,625	3,205
10	430	1,598	1,168	430	1,394	964	430	782	352
IRR:	--------184 percent---------			---------154 percent--------			---------54 percent---------		

n.a. = not applicable

a. Credit availability limits for cases A1 and A4 were reduced in relation to the base case by Q50 and Q200, respectively.

b. For a discussion of cost data refer to Section

c. Total benefit is computed as the stream of net income with insurance (W) minus without insurance (W/o). Sources of data are tables

Table 5B-5. Effect of Assumption on the Availability of Working Capital on the Internal Rate of Return (IRR)[a]

(Quetzales)

	W: Base (50% coverage) W/o: Base			W: C1 (50% coverage) W/o: Base			W: C3 (50% coverage) W/o: Base			W: C4 (50% coverage) W/o: Base		
Year	Total cost[b]	Total benefit[c]	Net benefit	Total cost[b]	Total benefit[c]	Net benefit	Total cost[b]	Total benefit[c]	Net benefit	Total cost[b]	Total benefit[c]	Net benefit
0	50	n.a.	-50	50	n.a.	-50	50	n.a.	-50	50	n.a.	-50
1	160	76	-84	160	74	-86	160	55	-105	160	46	-114
2	275	355	80	275	342	67	275	239	-36	275	188	-87
3	350	1,328	975	350	1,252	902	350	995	645	350	865	515
4	370	1,915	1,545	370	1,813	1,443	370	1,452	1,082	370	1,274	904
5	380	895	515	380	865	485	380	490	110	380	300	-80
6	390	458	68	390	488	98	390	465	75	390	458	68
7	400	-105	-505	400	-38	-438	400	-57	-457	400	-76	-476
8	410	756	346	410	780	370	410	756	346	410	744	334
9	420	7,366	6,946	420	6,916	6,496	420	5,423	5,003	420	4,669	4,249
10	430	1,598	1,168	430	1,615	1,185	430	1,292	862	430	1,122	692
IRR:	------184 percent------			------175 percent-------			------125 percent-------			-------99 percent-------		

n.a. = not applicable

a. Working capital limits for cases C1, C3, and C4 were reduced in relation to the base case by Q25, Q75, and Q100, respectively.

b. For a discussion of cost data refer to Section

c. Total benefit is computed as the stream of net income with insurance (W) minus without insurance (W/o). Sources of data are tables

APPENDIX B-6. THE LINEAR PROGRAM TABLEAU

Tables 6B-1 and 6B-2 are pictures of the LP matrix tableaux for the with and without insurance cases. Nonzero coefficients are represented with letters indicating the size of the coefficient. The ranges of values indicated by the various letters are presented in table 6B-3. The LP column and row abbreviations are defined in table 6B-4. In table 6B-5 the actual coefficients used in the linear programming model are displayed for the with insurance case.[1]

Table 6B-3. Definition of Symbols Used in the Picture of the LP Tableaux

SUMMARY OF MATRIX

SYMBOL	RANGE		
Z	LESS THAN		.000001
Y	.000001	THRU	.000009
X	.000010		.000099
W	.000100		.000999
V	.001000		.009999
U	.010000		.099999
T	.100000		.999999
1	1.000000		1.000000
A	1.000001		10.000000
B	10.000001		100.000000
C	100.000001		1,000.000000
D	1,000.000001		10,000.000000
E	10,000.000001		100,000.000000
F	100,000.000001		1,000,000.000000
G	GREATER THAN		1,000,000.000000

1. These coefficients refer specifically to the formulation with a farm of between one and three hectares area and where the crop mix flexibility level is medium.

Table 6B-1. "Picture" of the LP Tableau for the With Insurance Case

		B1	B2	B1	C1	C2	C3	C1	C2	C3	C4	C1	C2	C3	N1	N2	N1	N2	N3	G1	G2	P1	P2	P1	P2	P3	W1	W2	W1	W2	W3	W4	W1	W2	W3	W4	LFR1	LFR2	LFR3	LFR4	LFA1	LFA2	LFA3	LFA4	LHR1	LHR2	LHR3	LHR4	TCL1	TCL2	TCL3	TCL4	LHRF1	IFA1	IFA2
NETINCX	N																																																									
EMPLOY	N	B	B	B	B	C	C	B	B	B	B	B	C	B	B	B	B	C	B	C	C	B	C	C	C	B	B	C	B	B	B	B	B	B																							
BNPT/C	E	A	A	A											A	T	A	T	A																																					
CNPT/C	E				A	B	B	B	B	B	B	B	B	B	B	B	B	B	B																																						
GLPT/C	E																			B	B																																				
POPT/C	E																					B	B	C	B																																
WHPT/C	E																										B	B	B	B	B	B	B	B	B																							
CIST	E								B																																																
CUST	E				B	B	B	B		B	B	B	B	B	B	B	B	B	B																																						
WIST	E																										C	C	C	C		C	C	C	B																							
WUST	E																										B				C																										
BIST	E																																																								
BUST	E	B	B	B											B	A	B	B	A																																						
PIST	E																					C	D	D																																
PUST	E																					C			D																																
GIST	E																																																								
GUST	E																			C	C																																				
INSDT	E		A				T	T	T	A			T					T	T	B	B	A	B	B	B			A	A	A	A	A	A	A	A																						
MACHCT	E											A	B	B																			B	B	B	B																						
ANMDAT	E	A	A	A	A			A		T	B						A		B	B	B						A	A			A	A	T	T		T																					
FVADST	E	A	A	A	A	A	B	A	A	B	B	A	B	B	A	A	A	B	A	B	B	B	B	B	B	B	A	B	B	B	B	B	B	B	B																						
FMHIMT	E		A					T	A		A	A		T			T					A		T	B			A			T																										
FHTOLT	E	T	A	A	A	A	A	A	A	A	A	A	A	A	A	T	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A																						
UREAT	E		A				B	B	B	A	B	B	B				B	B	B	B	C		A	C			B	C	B	B	B	B	B	B	B																						
FERTT	F		C				C	C	C	C	C	C	C				C	C	C	C	C		C	D	C		C	C	C	C	C	C	C	C	C																						
LBQ1T	Z		A	A	B	B	B	B	B	B	B	B	A			B	B	B	B	B	C	A	B	A	B	A	A	B	A	B		A		A																							
LBQ2T	E	A	A	B	B	B	B	B	B	B	B	B	B	B	A	B	B	B	B	A		B	B	B	B	B	B	B	B	B	B	B	B	B	B																						
LBQ3T	E	B	B	B	A	A	B	B	B	A	A	A	B	B	B	A	B	A	B	B	B	B	B	C	B	B	B	B	B	B	B	B	B	B	A																						
LBQ4T	E	A	B	A	B	B	B	B	B	A	B	B	B	B	B	A	B	B	B	C	C	B	B		B	B	B	B	B	B	B	B	B	B	B																						
LFR1L	L																																			1																						
LFR2L	L																																				1																					
LFR3L	L																																					1																				
LFR4L	L																																						1																			
LFA1L	L																																							1																		
LFA2L	L																																								1																	
LFA3L	L																																									1																
LFA4L	L																																										1														
LHR1L	L																																											1												
LHR2L	L																																												1											
LHR3L	L																																													1										
LHR4L	L																																														1									
TCL1T	E																																															1								
TCL2T	E																																			-1		-1			-1				1									
TCL3T	E																																				-1		-1			-1				1								
TCL4T	E																																					-1		-1			-1				1							
LHRF1	G																																						-1		-1			-1				1						

(continued --)

Table 6B-1 (continued)

		B1	B1	B2	C1	C2	C3	C1	C2	C2	C2	C4	C4	C4	N1	N1	N2	N2	N2	G1	G2	P1	P2	P2	P2	W1	W2	W2	W2	W4	W4	W4	W4	LFR1	LFR2	LFR3	LFR4	LAA1	LAA2	LAA3	LAA4	LHR1	LHR2	LHR3	LHR4	LLR1	LLR2	LLR3	LLR4	LFS1	LFS2	LFS3	LFS4	LFA1	LFA2
LHRF2	G																																																								
LHRF3	G																																																								
LHRF4	G																																																								
LSL1	L																																																								
LSL2	L																																																								
LSL3	L																																																								
LSL4	L																																																								
FCLL	L	A	A	A	A	B	B	A	A	A	A	A	B	A	A	A	A	B	A	B	B	A	B	B	B	A	A	B	A	A	A	A	A	A	-1	-1	-1	-1																		
LWKOL	L	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																						
LRNTL	L																																																								
LANDT	E																																																								
CRNUL	L				B	B	B	B	B	B	B	B	B	B	B	B	B	B	B																																						
WHTUL	L																									B	B	B	B	B	B	B	B	B																							
BNSUL	L	B	B	B											B	B	B	B	B																																						
POTUL	L																					B	B	B	B																																
GRLUL	L																			B	B																																				
CRNLI	G				B	B	B	B	B	B	B	B	B	B	B	B	B	B	B																																						
WHTLI	G																									B	B	B	B	B	B	B	B	B																							
BNSLI	G	B	B	B											B	B	B	B	B																																						
POTLI	G																					B	B	B	B																																
GRLLI	G																			B	B																																				
BANDLA	L																																																								
BANDLB	L																																																								
BANDLC	L																																																								
BANDLD	L																																																								
CASHOA	G																																																								
CASHOB	G																																																								
CASHOC	G																																																								
CASHOD	G																																																								
CSHEND	G																																																								
NETINC	E																																																								
OUT	E	1			1		1				1	1		1	1	1	1	1																	-T	-T	-T	-T	-T	-T	-T	-T	-T	-T	-T	-T				T	T	T	T	T	T
MICST	E	B	B	C	B	B	C	C	C	C	C	C	C	B	B	C	C	C	C	C	C	C	C	D	C	C	1	1	1	1	1		1																								
MINC	E	A	B	B	B	B	B	B	C	C	C	B	C	C	B	B	C	B	C	C	C	D	C	D	D	D	B	C	C	C	C	B	C	C	B																						
INCOME	E	B	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	D	D	D	D	D	D	C	C	C	C	C	C	C	C	C																						
INSUR	E							A	B	B			B	B			B	A	B	C	C																																			
INCDROP	L																																																								
MAXCOST	F																																																								
COST	G																																																								

(continued --)

Table 6B-1 (Continued)

		LFAS3	LFAS4	CISI	CUSI	WISI	WUSI	BISI	BUSI	PISI	PUSI	GISI	GUSI	INSDI	MACHCI	ANMDAI	FVADSI	FMHIMI	FHTOLI	UREAI	FERTI	LANDRI	LANDRO	CRNOMI	CRNSFL/C	WHTSFI/C	BNSSFL/C	POTSFL/C	GRLSFL/C	BNLNA/C	BNDLNB/C	BNDLNC/C	BNDLND/C	NETINCA	MITNC	INCIT	GNICI	COSTIx	COSTMAx	RHS2
NETINCx	N																																							
EMPLOY	N																																	1						
BNPT/C	E																									-1														
CNPT/C	E																							-1																
GLPT/C	E																											-1												
POPT/C	E																										-1													
WHPT/C	E																								-1															
CIST	E			-1																																				
CUST	E				-1																																			
WIST	E					-1																																		
WUST	E						-1																																	
BIST	E							-1																																
BUST	E								-1																															
PIST	E									-1																														
PUST	E										-1																													
GIST	E											-1																												
GUST	E												-1																											
INSDT	E													-1																										
MACHCT	E														-1																									
ANMDAT	E															-1																								
FVADST	E																-1																							
FMHIMT	E																	-1																						
FHTOLT	E																		-1																					
UREAT	E																			-1																				
FERTT	E																				-1																			
LBQ1T	E																					-1																		
LBQ2T	E																																							
LBQ3T	E																																							
LBQ4T	E																																							
LFR1L	L																																							
LFR2L	L																																							R
LFR3L	L																																							R
LFR4L	L																																							R
LFA1L	L																																							R
LFA2L	L																																							R
LFA3L	L	1																																						R
LFA4L	L		1																																					R
LHR1L	L																																							C
LHR2L	L																																							C
LHR3L	L																																							C
LHR4L	L																																							C
TCL1T	E																																							
TCL2T	E																																							
TCL3T	E																																							
TCL4T	E																																							
LHRF1	G																																							

(continued --)

Table 6B-1 (continued)

		LFAS3	LFAS4	CICUSI	CIUSI	WISUSI	WIUSI	BISUSI	BIUSI	PISUSI	PIUSI	GISUSI	GIUSI	INSDI	HACHI	ANMDI	AVDSI	FHMI	FHTOLI	UREAI	FERTI	LANDRI	LANDOI	CRDMI	CRNSI	WHTSI	BNSSI	PORSEI	GRLSEI	BNDLNA	BNNDRI	BNNDCI	BNNDLI	NNDEN	HITCI	INNCI	IGNCI	CGOSTI	OSMAI	RHSI
LHRF2	G																																								
LHRF3	G																																								
LHRF4	G																																								
LSL1	L																																								
LSL2	L																																								
LSL3	L	1																																							
LSL4	L		1																																						
FCLL	L																																								
LWKDL	L																					-1	1																		A
LRNTL	L																					1																			
LANDT	E																							1																	A
CRNUL	L																							-B																	
WHTUL	L																							-B																	
BNSUL	L																							-B																	
POTUL	L																																								
GRLUL	L																							-A																	
CRNLI	G																							-B																	
WHTLI	G																							-A																	
BNSLI	G																							-A																	
POTLI	G																																								
GRLLI	G																																								
BANDLA	L																													B											C
BANDLB	L																														B										C
BANDLC	L																															B									C
BANDLD	L																																B								C
CASHQA	G			-T-T			-T-T							-1-1-A-1-1-1-T-T																B					-T					
CASHQB	G				-T-T			-T-T																					B-C	B					-T					
CASHQC	G	T																													-C	B				-T					
CASHQD	G		T								-T-T																	B				-C	B		-T					
CSHEND	G																					-B	B		B	B	B						-C								
NETINC	E	T	T-T-T-T-T-T-T-T-T-T-T-T-T-1-1-A-1-1-1-T-T-B																				B		B	B	B	B	B-A-A-A-A-1											
OUT	E																																								
MICST	E																																				-1				
MINC	F																																		-1						
INCOME	E																																			-1					
INSUR	E																																				-1				
INCDROP	L																																					-1			
MAXCOST	E																																		-1		T				
COST	G																																						1	C	
																																					-1	1	B		

Table 6B-2. "Picture" of the LP Tableau for the Without Insurance Case

		B11	B12	B21	C11	C12	C13	C21	C22	C23	C24	C41	C42	C43	N11	N12	N21	N22	N23	G21	G22	P11	P21	P22	P23	W11	W21	W22	W23	W24	W41	W42	W43	W44
NETINCX	N																																	
EMPLOY	N	B	B	B	B	C	C	B	B	B	B	B	C	B	B	B	B	C	B	C	C	B	C	C	C	B	B	C	B	B	B	B	B	B
BNPT/C	E	A	A	A											A	T	A	T	A															
CNPT/C	E				A	B	B	B	B	B	B	B	B	B	B	B	B	B	B															
GLPT/C	E																			B	B													
POPT/C	E																					B	B	C	B									
WHPT/C	E																									B	B	B	B	B	B	B	B	B
CIST	E								B																									
CUST	E				B	B	B	B		B	B	B	B	B	B	B	B	B	B															
WIST	E																									C	C	C	C		C	C	C	B
WUST	E																									B				C				
BIST	E																																	
BUST	E	B	B	B											B	A	B	B	A															
PIST	E																					C	D	D										
PUST	E																					C			D									
GIST	E																																	
GUST	E																			C	C													
INSDT	E			A				T	T	T	A			T					T	B	B	A	B	B	B		A	A	A	A	A	A	A	A
MACHCT	E											A	B	B																	B	B	B	B
ANHDAT	E	A	A	A	A			A		T	B						A		B	B	B					A	A		A	A	T	T		T
FVADST	E	A	A	A	A	A	B	A	A	B	B	A	B	B	A	A	A	B	A	B	B	B	B	B	B	A	B	B	B	B	B	B	B	B
FMHIMT	E			A				T	A		A	A		T			T				A		T	B			A			T				
FHTOLT	E	T	A	A	A	A	A	A	A	A	A	A	A	A	A	T	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
UREAT	E			A				B	B	B	A	B	B	B			B	B	B	B	C		A	C			B	C	B	B	B	B	B	B
FERTT	E			C				C	C	C	C	C	C	C			C	C	C	C	C		C	D	C		C	C	C	C	C	C	C	C
LBQ1T	E		A	A	B	B	B	B	B	B	B	B	B	A		B	B	B	B	B	C	A	B	A	B	A	A	B	A	B		A		A
LBQ2T	E	A	A	B	B	B	B	B	B	B	B	B	B	B	B	A	B	B	B	A		B	B	B	B	B	B	B	B	B	B	B	B	B
LBQ3T	E	B	B	B	A	A	B	B	B	A	A	A	B	B	B	A	B	A	B	B	B	B	B	C	B	B	B	B	B	B	B	B	A	B
LBQ4T	E	A	B	A	B	B	B	B	B	A	B	B	B	B	B	A	B	B	B	C	C	B	B		B	B	B	B	B	B	B	B	B	B
LFR1L	L																																	
LFR2L	L																																	
LFR3L	L																																	
LFR4L	L																																	
LFA1L	L																																	
LFA2L	L																																	
LFA3L	L																																	
LFA4L	L																																	
LHR1L	L																																	
LHR2L	L																																	
LHR3L	L																																	
LHR4L	L																																	
TCL1T	E																																	
TCL2T	E																																	
TCL3T	E																																	
TCL4T	E																																	
LHRFI	G																																	

		LFRI1	LFRI2	LFRI3	LFRI4	LFAI1	LFAI2	LFAI3	LFAI4	LHRI1	LHRI2	LHRI3	LHRI4	TLBI1	TLBI2	TLBI3	TLBI4	LFRS1	LFRS2	LFRS3	LFRS4	LFAS1	LFAS2
NETINCX	N																						
EMPLOY	N																						
BNPT/C	E																						
CNPT/C	E																						
GLPT/C	E																						
POPT/C	E																						
WHPT/C	E																						
CIST	E																						
CUST	E																						
WIST	E																						
WUST	E																						
BIST	E																						
BUST	E																						
PIST	E																						
PUST	E																						
GIST	E																						
GUST	E																						
INSDT	E																						
MACHCT	E																						
ANHDAT	E																						
FVADST	E																						
FMHIMT	E																						
FHTOLT	E																						
UREAT	E																						
FERTT	E																						
LBQ1T	E													-1									
LBQ2T	E														-1								
LBQ3T	E															-1							
LBQ4T	E																-1						
LFR1L	L	1																1					
LFR2L	L		1																1				
LFR3L	L			1																1			
LFR4L	L				1																1		
LFA1L	L					1																1	
LFA2L	L						1																1
LFA3L	L							1															
LFA4L	L								1														
LHR1L	L									1													
LHR2L	L										1												
LHR3L	L											1											
LHR4L	L												1										
TCL1T	E	-1				-1				-1				1									
TCL2T	E		-1				-1				-1				1								
TCL3T	E			-1				-1				-1				1							
TCL4T	E				-1				-1				-1				1						
LHRFI	G	-1				-1				1													

(continued --)

Table 6B-2 (continued)

		BB11	BB12	BC21	CC11	CC13	CC21	CC22	CC23	CC24	CC41	CC42	CC43	CN11	NN12	NN21	NN22	NN23	GG21	GG22	PP11	PP12	PP22	PP23	WW11	WW12	WW22	WW23	WW24	WW41	WW42	WW43	WW44	LLFR11	LLFR12	LLFR13	LLFR14	LLFA11	LLFA12	LLFA13	LLFA14	LLHR11	LLHR12	LLHR13	LLHR14	TTLR11	TTLR12	TTLR13	TTLR14	LLFS11	LLFS12	LLFS13	LLFS14	LLFA11	LLFA12
LHRF2	G																																																							
LHRF3	G																																																							
LHRF4	G																																																							
LSL1	L																																																							
LSL2	L																																																							
LSL3	L																																																							
LSL4	L																																																							
FCLL	L	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
LWKDL	L	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-1	-1	-1	-1																				
LRNTL	L																																																							
LANDT	E																																																							
CRNUL	L				B	B	B	B	B	B	B	B	B	B	B	B	B	B																																							
WHTUL	L																																																							
BNSUL	L	B	B	B																					B	B	B	B	B	B	B	B	B																								
POTUL	L													B	B	B	B	B																																							
GRLUL	L																				B	B	B	B																																
CRNLL	G				B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B																																					
WHTLL	G																																																							
BNSLL	G	B	B	B																					B	B	B	B	B	B	B	B	B																								
POTLL	G													B	B	B	B	B																																							
GRLLL	G																				B	B	B	B																																
BANDLA	L																		B	B																																				
BANDLB	L																																																							
BANDLC	L																																																							
BANDLD	L																																																							
CASHQA	G																																																							
CASHQB	G																																																							
CASHQC	G																																																							
CASHQD	G																																																							
CSHEND	G																																																							
NETINC	E																																																							
OUT	E	1			1		1				1	1		1	1	1	1	1																-T	-T	-T	-T	-T	-T	-T	-T	-T	-T	-T	-T					1			T	
MCST	E	B	B	C	B	B	C	C	C	C	C	C	C	C	B	B	C	C	C	C	C	C	D	C	C	C	C	C	C	C		1																T	T	T	T	T	T	T	T
MINC	E	A	B	B	H	H	B	B	H	H	B	B	B	B	B	B	C	B	B	C	C	C	D	D	H	C	C	C	C	H	C	C	C																								
INCOME	E	B	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	D	D	C	C	C	C	C	C	C	C	H																								
INSUR	E						A	B	B			B	B				H	A	B	C	C	D	D	D	C								C																							
INCDROP	L																																																							
MAXCOST	E																																																							
COST	G																																																							

(continued --)

Table 6B-2 (continued)

		LFAS3	LFAS4	CIUSI	CUUSI	WIUSI	WUUSI	BIUSI	BUUSI	PIUSI	PUUSI	GIUSI	GUUSI	INSDI	MACHCI	ANMDAI	FVADSI	FMHIMI	FHTOLI	UREATI	FERTTI	LANDRI	LANDRO	CRNOPMIx	CRNSFL/C	WHTSSL/C	WNSSEL/C	PDTSSL/C	GRSSL/C	HNDLNA/C	HNDLNB/C	HNDLNC/C	HNDLND/C	NETINCA	HINCI	INCI	GINCI	COSTI	COSTMAx	RHS2
NETINCX	N																																							
EMPLOY	N																																	1						
BNPT/C	E																									-1														
CNPT/C	E																							-1																
GLPT/C	E																												-1											
FOPT/C	E																											-1												
WHPT/C	E																								-1															
CIST	E			-1																																				
CUST	E				-1																																			
WIST	E					-1																																		
WUST	E						-1																																	
BIST	E							-1																																
BUST	E								-1																															
PIST	E									-1																														
PUST	E										-1																													
GIST	E											-1																												
GUST	E												-1																											
INSDT	E													-1																										
MACHCT	E														-1																									
ANMDAT	E															-1																								
FVADST	E																-1																							
FMHIMT	E																	-1																						
FHTOLT	E																		-1																					
UREAT	E																			-1																				
FERTT	E																				-1																			
LBO1T	E																					-1																		
LBO2T	E																						-1																	
LBO3T	E																							-1																
LBO4T	E																								-1															
LFR1L	L																																							
LFR2L	L																																						R	
LFR3L	L																																						R	
LFR4L	L																																						R	
LFA1L	L																																						R	
LFA2L	L																																						R	
LFA3L	L	1																																					R	
LFA4L	L		1																																				R	
LHR1L	L																																						C	
LHR2L	L																																						C	
LHR3L	L																																						C	
LHR4L	L																																						C	
TCL1T	E																																							
TCL2T	E																																							
TCL3T	E																																							
TCL4T	E																																							
LHRF1	G																																							

(continued --)

Table 6B-2 (continued)

		LHRF3	LHRF4	CIRCUS	CIRCUS	WIRUSS	WIRUSS	BHRUSS	BHRUSS	PHRUSS	PHRUSS	GIRUSS	GIRUSS	INSDII	MACHII	MANDII	FAVDII	FHMIII	FHTIII	UREAII	FRATII	LANDII	LARDII	LORMII	CRNFII	WHTFII	BNSFII	POTFII	GRLFII	BNDLLA	BNDLLB	BNDLLC	BNDLLD	BNDLEI	BNDLEI	HNNINI	INCNII	CONSIT	GSTMAX	RHS2
LHRF2	G																																							
LHRF3	G																																							
LHRF4	G																																							
LSL1	L																																							
LSL2	L																																							
LSL3	L	1																																						
LSL4	L		1																																					
FCLL	L																																							
LWKDL	L																					-1	1																	
LRNTL	L																					1																		A
LANDT	E																							1																
CRNUL	L																							-B																A
WHTUL	L																							-B																
BNSUL	L																							-B																
POTUL	L																							-A																
GRLUL	L																							-A																
CRNLI	G																							-B																
WHTLI	G																							-A																
BNSLI	G																							-A																
POTLI	G																																							
GRLLI	G																																							
BANDLA	L																													B										C
BANDLB	L																														B									C
BANDLC	L																															B								C
BANDLD	L																																B							C
CASHQA	G		-T-T		-T-T					-1-1-A-1-1-1-T-T																				B				-T				
CASHQB	G			-T-T		-T-T																													-T				
CASHQC	G	T																												B-C	B				-T				
CASHQD	G		T						-T-T																						-C	B			-T				
CSHEND	G																									B						-C	B		-T				
NETINC	E	T	T-T-T-T-T-T-T-T-T-T-T-T-1-1-A-1-1-1-T-T																			-B	B		B	B	B						-C						
OUT	E																					-B	B		B	B	B	B	B-A-A-A-A-1										
MCST	E																																							
MINC	E																																				-1			
INCOME	E																																		-1					
INSUR	E																																			-1				
INCDROP	L																																			-1				
MAXCOST	E																																		-1		T			
COST	G																																					1	C	
																																					-1	1	B	

Table 6B-4. Definition of LP Column and Row Abbreviations

ROWS

ABBREVIATION	DEFINITION
BNPT/C	Bean Production Transfer
CNPT/C	Corn Production Transfer
GLPT/C	Garlic Production Transfer
POPT/C	Potato Production Transfer
WHPT/C	Wheat Production Transfer
CIST	Improved Corn Seed Transfer
CUST	Unimproved Corn Seed Transfer
WIST	Improved Wheat Seed Transfer
WUST	Unimproved Wheat Seed Transfer
BIST	Improved Bean Seed Transfer
BUST	Unimproved Bean Seed Transfer
PIST	Improved Potato Seed Transfer
PUST	Unimproved Potato Seed Transfer
GIST	Improved Garlic Seed Transfer
GUST	Unimproved Garlic Seed Transfer
INSDT	Insecticide Cost Transfer
MACHCT	Machinery Cost Transfer
ANMDAT	Animal Days Transfer
FVADST	Administrative Services Transfer
FMHIMT	Machinery and Implement Depreciation Transfer
FHTOLT	Hand Tool Depreciation Transfer
UREAT	Urea Transfer
FERTT	Other Fertilizers Transfer

NOTE: A suffix of "/C" in an abbreviation name indicates that the key coefficients of the relevant row or column have been scaled by a factor of 100.

Table 6B-4 (continued)

ROWS

ABBREVIATION	DEFINITION
LANDT	Arable Land Transfer
CRNUL	Corn Area Upper Limit
WHTUL	Wheat Area Upper Limit
BNSUL	Beans Area Upper Limit
POTUL	Potatoes Area Upper Limit
GRLUL	Garlic Area Upper Limit
CRNLL	Corn Area Lower Limit
WHTLL	Wheat Area Lower Limit
BNSLL	Beans Area Lower Limit
POTLL	Potatoes Area Lower Limit
GRLLL	Garlic Area Lower Limit
BANDLA	BANDESA Loan Limit Quarter 1
BANDLB	BANDESA Loan Limit Quarter 2
BANDLC	BANDESA Loan Limit Quarter 3
BANDLD	BANDESA Loan Limit Quarter 4
OTHLLA	Other Loan Limit Quarter 1
OTHLLB	Other Loan Limit Quarter 2
OTHLLC	Other Loan Limit Quarter 3
OTHLLD	Other Loan Limit Quarter 4
CASHQA	Cash Balance Quarter 1
CASHQB	Cash Balance Quarter 2
CASHQC	Cash Balance Quarter 3
CASHQD	Cash Balance Quarter 4
CSHEND	Ending Cash Balance
NETINCX	Net Income Objective Function
NETINC	Net Income Transfer
EMPLOY	Employment Transfer
VALUE	Value of Production Transfer
TAST	Technical Assistance Transfer
VALND	Value of Land Transfer

Table 6B-4 (continued)

ROWS

ABBREVIATION	DEFINITION
LBQ1T	Crop Labor Input Quarter 1 Transfer
LBQ2T	Crop Labor Input Quarter 2 Transfer
LBQ3T	Crop Labor Input Quarter 3 Transfer
LBQ4T	Crop Labor Input Quarter 4 Transfer
LFR1L	Farmer Labor Input Quarter 1 Limit
LFR2L	Farmer Labor Input Quarter 2 Limit
LFR3L	Farmer Labor Input Quarter 3 Limit
LFR4L	Farmer Labor Input Quarter 4 Limit
LFA1L	Family Labor Input Quarter 1 Limit
LFA2L	Family Labor Input Quarter 2 Limit
LFA3L	Family Labor Input Quarter 3 Limit
LFA4L	Family Labor Input Quarter 4 Limit
LHR1L	Hired Labor Input Quarter 1 Limit
LHR2L	Hired Labor Input Quarter 2 Limit
LHR3L	Hired Labor Input Quarter 3 Limit
LHR4L	Hired Labor Input Quarter 4 Limit
TCL1T	Total Crop Labor Transfer Quarter 1
TCL2T	Total Crop Labor Transfer Quarter 2
TCL3T	Total Crop Labor Transfer Quarter 3
TCL4T	Total Crop Labor Transfer Quarter 4
LHRF1	Hired Labor Lower Limit Quarter 1
LHRF2	Hired Labor Lower Limit Quarter 2
LHRF3	Hired Labor Lower Limit Quarter 3
LHRF4	Hired Labor Lower Limit Quarter 4
LSL1	Family Labor Sale Limit Quarter 1
LSL2	Family Labor Sale Limit Quarter 2
LSL3	Family Labor Sale Limit Quarter 3
LSL4	Family Labor Sale Limit Quarter 4
FCLL	Farmer Crop Labor Lower Limit
LWKDL	Arable Land Limit
LRNTL	Land Rented In Limit

Table 6B-4 (continued)

COLUMNS

ABBREVIATION	DEFINITION
BEANP11	Bean Production Activity
BEANP12	Bean Production Activity
BEANP21	Bean Production Activity
CORNP11	Corn Production Activity
CORNP12	Corn Production Activity
CORNP13	Corn Production Activity
CORNP21	Corn Production Activity
CORNP22	Corn Production Activity
CORNP23	Corn Production Activity
CORNP24	Corn Production Activity
CORNP41	Corn Production Activity
CORNP42	Corn Production Activity
CORNP43	Corn Production Activity
CNBNP11	Corn and Beans Production Activity
CNBNP12	Corn and Beans Production Activity
CNBNP21	Corn and Beans Production Activity
CNBNP22	Corn and Beans Production Activity
CNBNP23	Corn and Beans Production Activity
GARLP21	Garlic Production Activity
GARLP22	Garlic Production Activity
POTAP11	Potatoes Production Activity
POTAP21	Potatoes Production Activity
POTAP22	Potatoes Production Activity
POTAP23	Potatoes Production Activity
WHEAP11	Wheat Production Activity
WHEAP21	Wheat Production Activity
WHEAP22	Wheat Production Activity
WHEAP23	Wheat Production Activity
WHEAP24	Wheat Production Activity
WHEAP41	Wheat Production Activity

Table 6B-4 (continued)

COLUMNS

ABBREVIATIONS	DEFINITION
WHEAP42	Wheat Production Activity
WHEAP43	Wheat Production Activity
WHEAP44	Wheat Production Activity
LFRI1	Farmer Labor Input Quarter 1
LFRI2	Farmer Labor Input Quarter 2
LFRI3	Farmer Labor Input Quarter 3
LFRI4	Farmer Labor Input Quarter 4
LFAI1	Family Labor Input Quarter 1
LFAI2	Family Labor Input Quarter 2
LFAI3	Family Labor Input Quarter 3
LFAI4	Family Labor Input Quarter 4
LHRI1	Hired Labor Input Quarter 1
LHRI2	Hired Labor Input Quarter 2
LHRI3	Hired Labor Input Quarter 3
LHRI4	Hired Labor Input Quarter 4
TLBI1	Total Labor Input Quarter 1
TLBI2	Total Labor Input Quarter 2
TLBI3	Total Labor Input Quarter 3
TLBI4	Total Labor Input Quarter 4
LFRS1	Farmer Labor Sale Quarter 1
LFRS2	Farmer Labor Sale Quarter 2
LFSR3	Farmer Labor Sale Quarter 3
LFSR4	Farmer Labor Sale Quarter 4
LFAS1	Family Labor Sale Quarter 1
LFAS2	Family Labor Sale Quarter 2
LFAS3	Family Labor Sale Quarter 3
LFAS4	Family Labor Sale Quarter 4
CISI	Improved Corn Seed Input
CUSI	Unimproved Corn Seed Input
WISI	Improved Wheat Seed Input
WUSI	Unimproved Wheat Seed Input

Table 6B-4 (continued)

COLUMNS

ABBREVIATION	DEFINITION
BISI	Improved Bean Seed Input
BUSI	Unimproved Bean Seed Input
PISI	Improved Potato Seed Input
PUSI	Unimproved Potato Seed Input
GISI	Improved Garlic Seed Input
GUSI	Unimproved Garlic Seed Input
INSDI	Insecticide Cost Input
MACHCI	Machinery Cost Input
ANMDAI	Animal Days Input
FVADSI	Administrative Services Input
FMHIMI	Value of Machinery and Implements Input
FHTOLI	Value of Hand Tools Input
UREAI	Urea Input
FERTI	Other Fertilizers Input
LANDRI	Land Rented In
LANDRO	Land Rented Out
CROPMIX	Crop Mix Flexibility Percentage Limits
CRNSEL/C	Corn Production
WHTSEL/C	Wheat Production
BNSSEL/C	Bean Production
POTSEL/C	Potato Production
GELSEL/C	Garlic Production
BNDLNA/C	BANDESA Loan Quarter 1
BNDLNB/C	BANDESA Loan Quarter 2
BNDLNC/C	BANDESA Loan Quarter 3
BNDLND/C	BANDESA Loan Quarter 4
OTHLNA/C	Other Loan Quarter 1
OTHLNB/C	Other Loan Quarter 2
OTHLNC/C	Other Loan Quarter 3
OTHLND/C	Other Loan Quarter 4

Table 6B-4 (continued)

ABBREVIATION	DEFINITION
SAVDA/C	Savings Deposits Quarter 1
SAVDB/C	Savings Deposits Quarter 2
SAVDC/C	Savings Deposits Quarter 3
SAVDD/C	Savings Deposits Quarter 4
NETINCA	Net Income Accounting Activity
RHS2	1-3 Hectare Right Hand Side

Table 6B-5. Crop Insurance Linear Programming Model Coefficients

	B11	B12	B21	C11	C12	C13	C21	C22	I....I
EMPLOY	19.77890	65.33060	54.56270	75.33200	101.28880	183.87880	88.91210	86.47280	EMPLOY
BNPT/C	1.03430	4.25900	7.18660	.	.	.	.	.	BNPT/C
CNPT/C	.	.	.	8.43670	11.92820	17.87510	15.52250	17.33780	CNPT/C
CIST	.	.	.	.	.	.	.	34.78060	CIST
CUST	.	.	.	19.68820	66.87390	36.63110	36.25190	.	CUST
BUST	16.67000	47.37690	57.64380	.	.	.	.	.	BUST
INSDT	.	.	2.33310	.	.	.	.15930	.14400	INSDT
ANMDAT	2.77450	1.46400	6.17170	1.17800	.	.	1.07280	.	ANMDAT
FVADST	1.79580	5.60290	8.03500	4.48880	7.06450	12.01130	8.64420	8.12300	FVADST
FMHIMT	.	.	2.43020	.	.	.	.22260	5.61980	FMHIMT
FHTOLT	.88530	2.88140	6.96560	3.99560	3.90390	4.12160	3.12930	4.42440	FHTOLT
UREAT	.	.	9.72440	.	.	.	30.81030	41.84720	UREAT
FERTT	.	.	205.62240	.	.	.	227.85920	210.44790	FERTT
LBQ1T	.	5.35470	9.64120	25.20380	33.29990	59.21520	29.15530	28.94660	LBQ1T
LBQ2T	2.48430	6.72480	17.44740	25.20150	26.69940	46.05580	26.17180	25.13020	LBQ2T
LBQ3T	12.05720	36.03150	20.08700	6.17326	9.07030	13.19640	11.32930	15.00190	LBQ3T
LBQ4T	5.23740	17.22100	7.40450	18.74710	32.21540	65.41150	22.25120	17.38950	LBQ4T
FCLL	1.97790	6.53310	5.45630	7.53320	10.12890	18.38790	8.89120	8.64730	FCLL
LWKDL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	LWKDL
CRNDL	.	.	.	100.00000	100.00000	100.00000	100.00000	100.00000	CRNDL
BNSDL	100.00000	100.00000	100.00000	.	.	.	.	.	BNSDL
CRNLI	.	.	.	100.00000	100.00000	100.00000	100.00000	100.00000	CRNLI
BNSLI	100.00000	100.00000	100.00000	.	.	.	.	.	BNSLI
OUT	1.00000	.	.	1.00000	.	1.00000	.	.	OUT
MICST	24.60000	65.30000	112.10000	61.60000	87.10000	137.90000	122.90000	127.50000	MICST
MINC	7.40000	30.60000	51.60000	20.60000	29.10000	43.60000	94.70000	105.75000	MINC
INCOME	29.70000	122.20000	206.30000	102.90000	145.50000	218.10000	189.40000	211.50000	INCOME
INSUR	.	.	.	.	.	.	9.90000	11.10000	INSUR

(continued --)

Table 6B-5 (continued)

	C23	C24	C41	C42	C43	M11	M12	M21	?....1
EMPLOY	78.46520	80.11220	59.68320	101.92840	57.31000	54.33600	29.72210	67.92200	EMPLOY
BNPT/C	.	.	.	.	.	7.36810	.94310	4.34200	BNPT/C
CNPT/C	23.73060	16.46030	16.03890	35.05860	23.38170	15.77720	10.41840	21.46500	CNPT/C
CUST	23.31620	26.29250	24.14070	58.82120	26.64670	14.78000	18.78520	21.87350	CUST
BUST	.	.	.	.	.	13.48000	6.76910	22.19230	BUST
INSDT	.32670	1.24650	.	.	.25670	.	.	.	INSDT
MACHCT	.	.	7.93750	31.22240	86.07840	.	.	.	MACHCT
ANMDAT	.49100	21.40040	.	.	.	.	.	1.29310	ANMDAT
FVADST	11.09440	10.66700	9.04990	13.39870	16.26330	4.18800	2.12320	8.49940	FVADST
FMHIMT	.	1.29430	2.13660	.	.53670	.	.	.24150	FMHIMT
FHTOLT	1.73920	8.10490	2.14470	5.44010	2.39000	1.32000	.60850	1.72280	FHTOLT
UREAT	79.63500	9.40340	31.60190	28.02880	63.55670	.	.	69.21580	UREAT
FERTT	501.02200	234.62610	351.67430	291.34200	393.41330	.	.	228.74990	FERTT
LBQ1T	45.98100	17.12590	13.07370	23.42210	8.68000	.	18.21890	10.46860	LBQ1T
LBQ2T	20.34080	40.65340	23.67890	26.52870	20.15670	29.57600	4.79900	29.26940	LBQ2T
LBQ3T	5.73590	5.82230	6.69060	25.81700	16.25670	12.20600	2.16320	10.56120	LBQ3T
LBQ4T	6.40190	16.50850	16.23630	26.16470	12.22000	12.56200	4.53940	17.61750	LBQ4T
FCLL	7.84650	8.01120	5.96830	10.19280	5.73100	5.43460	2.97220	6.79220	FCLL
LWKDL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	LWKDL
CRNUL	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	CRNUL
BNSUL	.	.	.	.	.	100.00000	100.00000	100.00000	BNSUL
CRNLI	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	CRNLI
BNSLI	.	.	.	.	.	100.00000	100.00000	100.00000	BNSLI
OUT	.	1.00000	1.00000	.	1.00000	1.00000	1.00000	1.00000	OUT
MICST	166.00000	149.20000	118.20000	203.90000	239.30000	26.90000	26.90000	127.90000	MICST
MINC	144.75000	100.75000	97.85000	213.85000	142.65000	80.80000	30.80000	193.25000	MINC
INCOME	289.50000	200.80000	195.70000	427.70000	285.30000	403.90000	154.20000	386.50000	INCOME
INSUR	15.20000	.	.	31.00000	20.70000	.	.	20.30000	INSUR

(continued --)

Table 6B-5 (continued)

	N22	N23	G21	G22	P11	P21	P22	P23	3....1
EMPLOY	110.41160	75.40100	184.41000	429.00000	68.81480	152.38350	243.62750	224.83390	EMPLOY
BNPT/C	.81680	2.22230	.	.	.	.	.	.	BNPT/C
CNPT/C	10.79260	13.82340	.	.	.	.	.	.	CNPT/C
GLPT/C	.	.	48.86420	56.01270	.	.	.	.	GLPT/C
POPT/C	.	.	.	.	70.33190	79.66090	218.49690	95.76470	POPT/C
CUST	28.87500	14.09400	.	.	.	.	.	.	CUST
BUST	12.15090	8.40780	.	.	.	.	.	.	BUST
PIST	.	.	.	.	709.06330	1179.0271	3054.0938	.	PIST
PUST	.	.	.	.	758.36910	.	.	1534.5483	PUST
GUST	.	.	465.27000	503.00000	.	.	.	.	GUST
INSDT	.	.50750	13.37000	38.13000	7.90690	15.97510	18.78200	15.69400	INSDT
ANMDAT	.	10.67360	19.31000	19.98000	.	.	.	.	ANMDAT
EVADST	10.14470	8.96520	24.54000	44.73000	30.16200	32.68040	73.77030	36.52200	EVADST
EMHIMT	.	.	.	4.77000	.	.15810	18.71760	.	EMHIMT
EHTOLT	2.31540	2.56690	5.87000	5.36000	3.13470	2.91330	3.94750	3.06400	EHTOLT
UREAT	12.98160	30.12040	77.12000	138.05000	.	9.18520	304.62840	.	UREAT
FERTT	221.90070	198.18850	511.34000	692.82000	.	730.82760	1071.1704	377.40580	FERTT
LBQ1T	40.22850	15.00870	41.79000	137.98000	1.30820	19.62360	8.06460	15.31600	LBQ1T
LBQ2T	33.89600	27.08220	3.72000	.	33.13890	68.02410	93.89630	97.24180	LBQ2T
LBQ3T	9.30210	11.86190	15.09000	14.17000	12.40570	50.51730	141.64620	70.08790	LBQ3T
LBQ4T	26.98290	24.42540	123.81000	276.85000	21.94040	14.20310	.	42.19400	LBQ4T
FCLL	11.04110	7.84010	18.44100	42.90000	6.88150	15.23830	24.36270	22.48340	FCLL
LWKDL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	LWKDL
CRNUL	100.00000	100.00000	.	.	.	.	.	.	CRNUL
BNSUL	100.00000	100.00000	.	.	.	.	.	.	BNSUL
POTUL	.	.	.	.	100.00000	100.00000	100.00000	100.00000	POTUL
GRLUL	.	.	100.00000	100.00000	.	.	.	.	GRLUL
CRNLL	100.00000	100.00000	.	.	.	.	.	.	CRNLL
BNSLL	100.00000	100.00000	.	.	.	.	.	.	BNSLL
POTLL	.	.	.	.	100.00000	100.00000	100.00000	100.00000	POTLL
GRLLL	.	.	100.00000	100.00000	.	.	.	.	GRLLL
OUT	1.00000	.	.	.	.	.	.	.	OUT
MICST	131.50000	129.30000	537.40000	796.40000	363.80000	472.70000	1038.8000	538.10000	MICST
MINC	77.55000	116.20000	929.65000	1065.6500	944.20000	1094.2000	2933.3000	1285.7000	MINC
INCOME	155.10000	232.40000	1859.3000	2131.3000	1258.9000	1458.9000	3911.1000	1714.2000	INCOME
INSUR	8.10000	12.20000	162.70000	186.50000	.	.	.	.	INSUR

(continued --)

Table 6B-5 (continued)

	W11	W21	W22	W23	W24	W41	W42	W43	4....1
EMPLOY	93.86120	90.34610	100.05380	55.00480	87.36000	81.67590	92.57640	55.25240	EMPLOY
WHPT/C	11.56630	11.86200	17.32500	22.82380	14.42860	13.08340	17.60900	17.06080	WHPT/C
WIST	196.06000	142.25450	319.29220	159.23400	.	181.12090	178.13770	120.77310	WIST
WUST	41.20390	.	.	.	112.28980	.	.	.	WUST
INSDT	.	1.62870	4.25870	5.35400	4.28390	8.02000	1.84500	4.23890	INSDT
MACHCT	.	.	.	.	.	18.11400	18.45140	18.87350	MACHCT
ANMDAT	2.54180	4.29910	.	4.27670	3.58770	.45900	.31580	.	ANMDAT
EVADST	8.80260	11.54430	16.01590	11.53520	11.30670	14.16100	13.87120	11.06300	EVADST
EMHIMT	.	1.68280	.	.	.17840	.	.	.	EMHIMT
EHTOLT	4.75530	2.86840	3.29410	3.84860	4.56020	2.95400	3.29870	3.42320	EHTOLT
UREAT	.	51.09870	268.25170	89.69680	70.81560	80.92990	58.88390	95.23810	UREAT
FERTT	.	294.78960	416.17460	381.12920	272.27170	303.75590	315.91870	282.35740	FERTT
LBQ1T	4.23290	9.88160	18.69990	2.75020	23.55240	.	7.64420	.	LBQ1T
LBQ2T	18.83790	18.70950	33.23080	20.37320	15.01820	30.89696	38.72090	18.27530	LBQ2T
LBQ3T	27.17280	29.46640	23.80430	19.67020	33.34140	18.07900	17.34740	9.48120	LBQ3T
LBQ4T	43.42710	32.28780	24.31640	12.21670	15.44800	32.70200	28.86110	27.49460	LBQ4T
FCLL	9.38610	9.03460	10.00540	5.50050	8.73600	8.16760	9.25760	5.52520	FCLL
LWKDL	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	LWKDL
WHTUL	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	WHTUL
WHTLL	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	100.00000	WHTLL
OUT	.	1.00000	1.00000	1.00000	1.00000	1.00000	.	1.00000	OUT
MICST	118.30000	156.00000	239.20000	157.90000	149.00000	163.70000	182.00000	148.90000	MICST
MINC	98.30000	100.80000	147.20000	193.90000	122.60000	90.30000	121.60000	148.90000	MINC
INCOME	204.70000	210.00000	306.70000	404.00000	255.40000	231.60000	311.70000	302.00000	INCOME

(continued --)

Table 6B-5 (continued)

	W44	LFRI1	LFRI2	LFRI3	LFRI4	LFAI1	LFAI2	LFAI3	5....1
EMPLOY	76.01410	.	.	.	.	.	.	.	EMPLOY
WHPT/C	13.67690	.	.	.	.	.	.	.	WHPT/C
WIST	86.78490	.	.	.	.	.	.	.	WIST
INSDT	1.62230	.	.	.	.	.	.	.	INSDT
MACHCT	13.16010	.	.	.	.	.	.	.	MACHCT
ANMDAT	.22410	.	.	.	.	.	.	.	ANMDAT
FVADST	10.11040	.	.	.	.	.	.	.	FVADST
FHTOLT	2.29600	.	.	.	.	.	.	.	FHTOLT
UHEAT	63.66820	.	.	.	.	.	.	.	UHEAT
FERTT	215.57410	.	.	.	.	.	.	.	FERTT
LBQ1T	7.93970	.	.	.	.	.	.	.	LBQ1T
LBQ2T	25.82790	.	.	.	.	.	.	.	LBQ2T
LBQ3T	24.15790	.	.	.	.	.	.	.	LBQ3T
LBQ4T	18.08860	.	.	.	.	.	.	.	LBQ4T
LFR1L	.	1.00000	.	.	.	.	.	.	LFR1L
LFR2L	.	.	1.00000	.	.	.	.	.	LFR2L
LFR3L	.	.	.	1.00000	.	.	.	.	LFR3L
LFR4L	.	.	.	.	1.00000	.	.	.	LFR4L
LFA1L	.	.	.	.	.	1.00000	.	.	LFA1L
LFA2L	.	.	.	.	.	.	1.00000	.	LFA2L
LFA3L	.	.	.	.	.	.	.	1.00000	LFA3L
TCL1T	.	1.00000-	.	.	.	1.00000-	.	.	TCL1T
TCL2T	.	.	1.00000-	.	.	.	1.00000-	.	TCL2T
TCL3T	.	.	.	1.00000-	.	.	.	1.00000-	TCL3T
TCL4T	.	.	.	.	1.00000-	.	.	.	TCL4T
LHRF1	.	1.00000-	.	.	.	1.00000-	.	.	LHRF1
LHRF2	.	.	1.00000-	.	.	.	1.00000-	.	LHRF2
LHRF3	.	.	.	1.00000-	.	.	.	1.00000-	LHRF3
LHRF4	.	.	.	.	1.00000-	.	.	.	LHRF4
FCLL	7.60140	1.00000-	1.00000-	1.00000-	1.00000-	.	.	.	FCLL
LWKDL	1.00000	.	.	.	.	.	.	.	LWKDL
WHTUL	100.00000	.	.	.	.	.	.	.	WHTUL
WHTLL	100.00000	.	.	.	.	.	.	.	WHTLL
NETINC	.	.38600-	.38600-	.38600-	.38600-	.36700-	.36700-	.36700-	NETINC
MICST	131.10000	.	.	.	.	.	.	.	MICST
MINC	94.40000	.	.	.	.	.	.	.	MINC
INCOME	242.10000	.	.	.	.	.	.	.	INCOME

(continued --)

Table 6B-5 (continued)

	LFAI4	LHRI1	LHRI2	LHRI3	LHRI4	TLRI1	TLRI2	TLRI3	6....1
LBQ1T	.	.	.	.	.	1.00000-	.	.	LBQ1T
LBQ2T	.	.	.	.	.	.	1.00000-	.	LBQ2T
LBQ3T	.	.	.	.	.	.	.	1.00000-	LBQ3T
LFA4L	1.00000	.	.	.	.	.	.	.	LFA4L
LHR1L	.	1.00000	.	.	.	.	.	.	LHR1L
LHR2L	.	.	1.00000	.	.	.	.	.	LHR2L
LHR3L	.	.	.	1.00000	.	.	.	.	LHR3L
LHR4L	.	.	.	.	1.00000	.	.	.	LHR4L
TCL1T	.	1.00000-	.	.	.	1.00000	.	.	TCL1T
TCL2T	.	.	1.00000-	.	.	.	1.00000	.	TCL2T
TCL3T	.	.	.	1.00000-	.	.	.	1.00000	TCL3T
TCL4T	1.00000-	.	.	.	1.00000-	.	.	.	TCL4T
LHRF1	.	1.00000	.	.	.	.	.	.	LHRF1
LHRF2	.	.	1.00000	.	.	.	.	.	LHRF2
LHRF3	.	.	.	1.00000	.	.	.	.	LHRF3
LHRF4	1.00000-	.	.	.	1.00000	.	.	.	LHRF4
CASHQA	.	.77200-	.	.	.	.	.	.	CASHQA
CASHQB	.	.	.77200-	.	.	.	.	.	CASHQB
CASHQC	.	.	.	.77200-	.	.	.	.	CASHQC
CASHQD	.	.	.	.	.77200-	.	.	.	CASHQD
NETINC	.36700-	.77200-	.77200-	.77200-	.77200-	.	.	.	NETINC

(continued --)

Table 6B-5 (continued)

	TLBI4	LFRS1	LFRS2	LFRS3	LFRS4	LFAS1	LFAS2	LFAS3	7....1
LBQ4T	1.00000-	.	.	.	.	.	.	.	LBQ4T
LFR1L	.	1.00000	.	.	.	.	.	.	LFR1L
LFR2L	.	.	1.00000	.	.	.	.	.	LFR2L
LFR3L	.	.	.	1.00000	.	.	.	.	LFR3L
LFR4L	.	.	.	.	1.00000	.	.	.	LFR4L
LFA1L	.	.	.	.	.	1.00000	.	.	LFA1L
LFA2L	.	.	.	.	.	.	1.00000	.	LFA2L
LFA3L	.	.	.	.	.	.	.	1.00000	LFA3L
TCL4T	1.00000	.	.	.	.	.	.	.	TCL4T
LSL1	.	1.00000	.	.	.	1.00000	.	.	LSL1
LSL2	.	.	1.00000	.	.	.	1.00000	.	LSL2
LSL3	.	.	.	1.00000	.	.	.	1.00000	LSL3
LSL4	.	.	.	.	1.00000	.	.	.	LSL4
CASHQA	.	.77200	.	.	.	.77300	.	.	CASHQA
CASHQB	.	.	.77200	.	.	.	.77300	.	CASHQB
CASHQC	.	.	.	.77200	.	.	.	.77300	CASHQC
CASHQD	.	.	.	.	.77200	.	.	.	CASHQD
NETINC	.	.77200	.77200	.77200	.77200	.73300	.73300	.73300	NETINC

(continued --)

Table 6B-5 (continued)

	LFAS4	CISI	CUSI	WISI	WUSI	BISI	BUSI	PISI	A....1
CISI	.	1.00000-	.	.	.	.	.	.	CISI
CUSI	.	.	1.00000-	.	.	.	.	.	CUSI
WISI	.	.	.	1.00000-	.	.	.	.	WISI
WUSI	.	.	.	.	1.00000-	.	.	.	WUSI
BISI	.	.	.	.	.	1.00000-	.	.	BISI
BUSI	.	.	.	.	.	.	1.00000-	.	BUSI
PISI	.	.	.	.	.	.	.	1.00000-	PISI
LFA4L	1.00000	.	.	.	.	.	.	.	LFA4L
LSL4	1.00000	.	.	.	.	.	.	.	LSL4
CASHQA	.	.20700-	.17500-	.	.	.37700-	.25900-	.	CASHQA
CASHQB	.	.	.	.16200-	.15400-	.	.	.17900-	CASHQB
CASHQD	.77300	.	.	.	.	.	.	.	CASHQD
NETINC	.73300	.20700-	.17500-	.16200-	.15400-	.37700-	.25900-	.17900-	NETINC

(continued --)

Table 6B-5 (continued)

	PUSI	GISI	GUSI	INSDI	MACHCI	ANMDAI	FVADSI	FMHIMI	9....1
PUSI	1.00000-	.	.	.	.	.	.	.	PUSI
GISI	.	1.00000-	.	.	.	.	.	.	GISI
GUSI	.	.	1.00000-	.	.	.	.	.	GUSI
INSDI	.	.	.	1.00000-	.	.	.	.	INSDI
MACHCI	.	.	.	.	1.00000-	.	.	.	MACHCI
ANMDAI	.	.	.	.	.	1.00000-	.	.	ANMDAI
FVADSI	.	.	.	.	.	.	1.00000-	.	FVADSI
FMHIMI	.	.	.	.	.	.	.	1.00000-	FMHIMI
CASHQA	.	.	.	1.00000-	1.00000-	1.62000-	1.00000-	1.00000-	CASHQA
CASHQB	.17900-	.	.	.	.	.	.	.	CASHQB
CASHQD	.	.23700-	.23700-	.	.	.	.	.	CASHQD
NETINC	.17900-	.23700-	.23700-	1.00000-	1.00000-	1.62000-	1.00000-	1.00000-	NETINC

(continued --)

Table 6B-5 (continued)

	FHTOLT	UREAT	FERTT	LANDRT	LANDRO	CROPHTX	CRNSEL/C	WHTSEL/C	10....1
CNPT/C	.	.	.	.	.	.	1.00000-	.	CNPT/C
WHPT/C	.	.	.	.	.	.	.	1.00000-	WHPT/C
FHTOLT	1.00000-	.	.	.	.	.	.	.	FHTOLT
UREAT	.	1.00000-	.	.	.	.	.	.	UREAT
FERTT	.	.	1.00000-	.	.	.	.	.	FERTT
LWKDL	.	.	.	1.00000-	1.00000	.	.	.	LWKDL
LRNTL	.	.	.	1.00000	.	.	.	.	LRNTL
LANDT	.	.	.	.	.	1.00000	.	.	LANDT
CRNUL	.	.	.	.	.	100.00000-	.	.	CRNUL
WHTUL	.	.	.	.	.	25.00000-	.	.	WHTUL
RNSUL	.	.	.	.	.	60.00000-	.	.	RNSUL
GRLUL	.	.	.	.	.	2.00000-	.	.	GRLUL
CRNLI	.	.	.	.	.	20.00000-	.	.	CRNLI
WHTLI	.	.	.	.	.	4.00000-	.	.	WHTLI
RNSLI	.	.	.	.	.	10.00000-	.	.	RNSLI
CASHOA	1.00000-	.13000-	.13000-	.	.	.	.	.	CASHOA
CSHEND	.	.	.	34.20000-	33.90000	.	12.20000	17.70000	CSHEND
NETINC	1.00000-	.13000-	.13000-	34.20000-	33.90000	.	12.20000	17.70000	NETINC

(continued --)

Table 6B-5 (continued)

	BNSSEL/C	POTSEL/C	GRLSEL/C	BNDLNA/C	BNDLNB/C	BNDLNC/C	BNDLND/C	NETINCA	11....1
NETINCX	.	.	.	.	.	.	.	1.00000	NETINCX
BNPT/C	1.00000-	.	.	.	.	.	.	.	BNPT/C
GLPT/C	.	.	1.00000-	.	.	.	.	.	GLPT/C
POPT/C	.	1.00000-	.	.	.	.	.	.	POPT/C
BANDLA	.	.	.	100.00000	.	.	.	.	BANDLA
BANDLB	.	.	.	.	100.00000	.	.	.	BANDLB
BANDLC	.	.	.	.	.	100.00000	.	.	BANDLC
BANDLD	.	.	.	.	.	.	100.00000	.	BANDLD
CASHQA	.	.	.	100.00000	.	.	.	.20000-	CASHQA
CASHQB	.	.	38.05000	102.00000-	100.00000	.	.	.20000-	CASHQB
CASHQC	.	.	.	.	102.00000-	100.00000	.	.20000-	CASHQC
CASHQD	.	17.90000	.	.	.	102.00000-	100.00000	.20000-	CASHQD
CSHEND	28.70000	.	.	.	.	.	102.00000-	.	CSHEND
NETINC	28.70000	17.90000	38.05000	2.00000-	2.00000-	2.00000-	2.00000-	1.00000-	NETINC

(continued --)

Table 6B-5 (continued)

	MINCI	INCI	GINC	COSTI	COSTMAX	RHS2	
LFR1L	.	.	.	.	.	72.00000	LFR1L
LFR2L	.	.	.	.	.	72.00000	LFR2L
LFR3L	.	.	.	.	.	72.00000	LFR3L
LFR4L	.	.	.	.	.	72.00000	LFR4L
LFA1L	.	.	.	.	.	74.00000	LFA1L
LFA2L	.	.	.	.	.	74.00000	LFA2L
LFA3L	.	.	.	.	.	74.00000	LFA3L
LFA4L	.	.	.	.	.	74.00000	LFA4L
LHR1L	.	.	.	.	.	128.00000	LHR1L
LHR2L	.	.	.	.	.	128.00000	LHR2L
LHR3L	.	.	.	.	.	128.00000	LHR3L
LHR4L	.	.	.	.	.	128.00000	LHR4L
LWKDL	.	.	.	.	.	1.80000	LWKDL
LANDT	.	.	.	.	.	1.80000	LANDT
BANDLA	.	.	.	.	.	524.00000	BANDLA
BANDLB	.	.	.	.	.	524.00000	BANDLB
BANDLC	.	.	.	.	.	524.00000	BANDLC
BANDLD	.	.	.	.	.	524.00000	BANDLD
MICST	.	.	.	1.00000-	.	.	MICST
MINC	1.00000-	.	.	.	.	.	MINC
INCOME	.	.	1.00000-	.	.	.	INCOME
INSUR	.	1.00000-	.	.	.	.	INSUR
INCDROP	1.00000-	.	.35000	.	.	.	INCDROP
MAXCOST	.	.	.	.	1.00000	400.00000	MAXCOST
COST	.	.	.	1.00000-	1.00000	50.00000	COST

12....1

APPENDIX B-7

This appendix contains the report writer program along with data tables. Tables INSUR and MY apply to the 50 percent coverage case only.

```
HAVERLY SYSTEMS INC LP/360 77193   VERS. J  MOD. B    SYSTEM DATE = 5/25/76          TIME   REAL 00100100   TASK 00100100
GENERATE,I
                                                                  00000210   TIME   REAL 00100100   TASK 00100100

    DICTIONARY
                                                                  00000220


      CLASS YR
         01                                                       00000230
         02                                                       00000240
         03                                                       00000250
         04                                                       00000260
         05                                                       00000270
         06                                                       00000280
         07                                                       00000290
         08                                                       00000300
         09                                                       00000310
         10                                                       00000320
                                                                  00000330


      CLASS K
         0                                                        00000340
         1                                                        00000350
         2                                                        00000360
         3                                                        00000370
         4                                                        00000380
         5                                                        00000390
         6                                                        00000400
         7                                                        00000410
         8                                                        00000420
         9                                                        00000430
         A                                                        00000440
         B                                                        00000450
         C                                                        00000460
         D                                                        00000470
         E                                                        00000480
         F                                                        00000490
                                                                  00000500


      CLASS CRP
                                                                  00000510
         B11  BEANP11
         B12  BEANP12                                             00000520
         B21  BEANP21                                             00000530
         C11  CORNP11                                             00000540
         C12  CORNP12                                             00000550
         C13  CORNP13                                             00000560
         C21  CORNP21                                             00000570
         C22  CORNP22                                             00000580
         C23  CORNP23                                             00000590
         C24  CORNP24                                             00000600
         C41  CORNP41                                             00000610
         C42  CORNP42                                             00000620
         C43  CORNP43                                             00000630
         N11  CNBNP11                                             00000640
         N12  CNBNP12                                             00000650
```

```
N22  CNBNP22
N23  CNBNP23                                    00000680
G21  GARLP21                                    00000690
G22  GARLP22                                    00000700
P11  POTAP11                                    00000710
P21  POTAP21                                    00000720
P22  POTAP22                                    00000730
P23  POTAP23                                    00000740
W11  WHEAP11                                    00000750
W21  WHEAP21                                    00000760
W22  WHEAP22                                    00000770
W23  WHEAP23                                    00000780
W24  WHEAP24                                    00000790
W41  WHEAP41                                    00000800
W42  WHEAP42                                    00000810
W43  WHEAP43                                    00000820
W44  WHEAP44                                    00000830
                                                00000840

CLASS A   STUBS
 1     EXPECTED NET INCOME                      00000850
 2     ADJUSTED NET INCOME                      00000860
 3     INSURANCE INDEMNITY                      00000870
 4     NET INCOME                               00000880
                                                00000890

CLASS B    TECHNOLOGY
 1                                              00000900
 2                                              00000910
 3                                              00000920
 4                                              00000930
DATA                                            00000940
                                                00000950

TABLE COST
     MCST                                       00000960
B11   24.6                                      00000970
B12   65.3                                      00000980
B21  112.1                                      00000990
C11   61.6                                      00001000
C12   87.1                                      00001010
C13  137.9                                      00001020
C21  113.                                       00001030
C22  116.4                                      00001040
C23  150.8                                      00001050
C24  149.2                                      00001060
C41  118.2                                      00001070
C42  172.9                                      00001080
C43  218.6                                      00001090
N11   46.1                                      00001100
                                                00001110
```

```
N12     26.9
N21    107.6                                                    00001120
N22    123.4                                                    00001130
N23    117.1                                                    00001140
G21    374.7                                                    00001150
G22    609.9                                                    00001160
P11    363.8                                                    00001170
P21    472.7                                                    00001180
P22   1038.8                                                    00001190
P23    538.1                                                    00001200
W11    118.3                                                    00001210
W21    156.                                                     00001220
W22    239.2                                                    00001230
W23    157.9                                                    00001240
W24    149.                                                     00001250
W41    183.7                                                    00001260
W42    182.                                                     00001270
W43    148.9                                                    00001280
W44    131.1                                                    00001290
                                                                00001300

   TABLE INSUR
     CUST50                                                     00001310
                                                                00001320
B11       .
B12       .
B21       .
C11       .
C12       .
C13       .
C21     9.94                                                    00001390
C22    11.10                                                    00001400
C23    15.20                                                    00001410
C24     0.                                                      00001420
C41     0.                                                      00001430
C42    31.01                                                    00001440
C43    20.68                                                    00001450
N11       .
N12       .
N21    20.29                                                    00001480
N22     4.65                                                    00001490
N23    12.20                                                    00001500
G21   162.69                                                    00001510
G22   186.49                                                    00001520
P11       .
P21       .
P22       .
P23       .
W11       .
W21       .
W22       .
W23       .
W24       .
```

```
W41      .
W42      .
W43      .
W44      .


   TABLE EY                                                          00001660
     INCOME                                                          00001670
B11     29.7                                                         00001680
B12    122.2                                                         00001690
B21    206.3                                                         00001700
C11    102.9                                                         00001710
C12    145.5                                                         00001720
C13    218.1                                                         00001730
C21    189.4                                                         00001740
C22    211.5                                                         00001750
C23    289.5                                                         00001760
C24    200.8                                                         00001770
C41    195.7                                                         00001780
C42    427.7                                                         00001790
C43    285.3                                                         00001800
N11    403.9                                                         00001810
N12    154.2                                                         00001820
N21    386.5                                                         00001830
N22    155.1                                                         00001840
N23    232.4                                                         00001850
G21   1859.3                                                         00001860
G22   2131.3                                                         00001870
P11   1258.9                                                         00001880
P21   1458.9                                                         00001890
P22   3911.1                                                         00001900
P23   1714.2                                                         00001910
W11    204.7                                                         00001920
W21    210.0                                                         00001930
W22    306.7                                                         00001940
W23    404.0                                                         00001950
W24    255.4                                                         00001960
W41    231.6                                                         00001970
W42    311.7                                                         00001980
W43    302.0                                                         00001990
W44    242.1                                                         00002000


   TABLE AY                                                          00002010
        01     02     03     04     05     06     07     08     09     10  00002020
B11     46.    27.     1.    40.     8.    24.    37.    14.    30.    40. 00002030
B12    189.   111.     6.   164.    33.    98.   150.    59.   125.   164. 00002040
B21    320.   188.    10.   276.    56.   165.   254.    99.   210.   276. 00002050
```

C11	107.	179.	132.	155.	132.	36.	36.	36.	179.	83.	00002060
C12	151.	253.	186.	220.	186.	51.	51.	51.	253.	118.	00002070
C13	227.	379.	279.	329.	279.	76.	76.	76.	379.	177.	00002080
C21	197.	318.	258.	258.	258.	76.	102.	76.	288.	136.	00002090
C22	220.	355.	288.	288.	288.	85.	114.	85.	321.	152.	00002100
C23	301.	486.	394.	394.	394.	116.	156.	116.	440.	208.	00002110
C24	209.	337.	273.	273.	273.	80.	108.	80.	305.	145.	00002120
C41	235.	286.	286.	286.	235.	78.	78.	78.	286.	129.	00002130
C42	513.	624.	624.	624.	513.	171.	171.	171.	624.	282.	00002140
C43	342.	417.	417.	417.	342.	114.	114.	114.	417.	188.	00002150
N11	420.	703.	517.	610.	517.	141.	141.	141.	703.	327.	00002160
N12	160.	268.	197.	233.	197.	54.	54.	54.	268.	125.	00002170
N21	402.	649.	526.	526.	526.	155.	209.	155.	587.	278.	00002180
N22	161.	261.	211.	211.	211.	62.	84.	62.	236.	112.	00002190
N23	242.	390.	316.	316.	316.	93.	126.	93.	353.	168.	00002200
G21	1432.	167.	4295.	3663.	800.	1748.	167.	1432.	3979.	1748.	00002210
G22	1641.	192.	4923.	4199.	916.	2003.	192.	1641.	4561.	2003.	00002220
P11	1259.	1800.	604.	1448.	1448.	1120.	1473.	1322.	1259.	906.	00002230
P21	1426.	2039.	684.	1640.	1640.	1269.	1668.	1497.	1426.	1027.	00002240
P22	3911.	5593.	1877.	4498.	4498.	3481.	4576.	4107.	3911.	2816.	00002250
P23	1714.	2451.	823.	1971.	1971.	1526.	2006.	1800.	1714.	1234.	00002260
W11	295.	86.	141.	104.	295.	199.	237.	141.	123.	199.	00002270
W21	302.	88.	145.	107.	302.	204.	244.	145.	126.	204.	00002280
W22	442.	129.	212.	156.	442.	298.	356.	212.	184.	298.	00002290
W23	582.	170.	279.	206.	582.	392.	469.	279.	242.	392.	00002300
W24	368.	107.	176.	130.	368.	248.	296.	176.	153.	248.	00002310
W41	338.	100.	155.	100.	338.	252.	283.	155.	100.	252.	00002320
W42	455.	134.	209.	134.	455.	340.	380.	209.	134.	340.	00002330
W43	441.	130.	202.	130.	441.	329.	368.	202.	130.	329.	00002340
W44	353.	104.	162.	104.	353.	264.	295.	162.	104.	264.	00002350

TABLE MY MINYLD		
B11	.	00002360
B12	.	00002370
B21	.	
C11	.	
C12	.	
C13	.	
C21	94.70	
C22	105.75	00002440
C23	144.75	00002450
C24	100.40	00002460
C41	97.85	00002470
C42	213.85	00002480
C43	142.65	00002490
N11	.	00002500
N12	.	
N21	193.25	
N22	77.55	00002530
N23	116.20	00002540
		00002550

```
 G21    929.65                                          00002560
 G22   1065.65                                          00002570
 P11       .
 P21       .
 P22       .
 P23       .
 W11       .
 W21       .
 W22       .
 W23       .
 W24       .
 W41       .
 W42       .
 W43       .
 W44       .
FORM LINE                                               00002701
```

```
INCORE MODE
000 CYLS. 002 TRKS. UICTDATA
00005 TABLES GENERATED
0011428   UNUSED CORE DEC.
```

```
FORM LINE                                               00002701
    W1=0.0                                              00002702
    W2=0.0                                              00002703
    W3=0.0                                              00002704
    W4=0.0                                              00002705
    W5=0.0                                              00002706
    W6=0.0                                              00002707
    Y1=0.0                                              00002708
    Y2=0.0                                              00002709
    Y3=0.0                                              00002710
    Y4=0.0                                              00002711
    Y5=0.0                                              00002712
    Y6=0.0                                              00002713
    Z1=0.0                                              00002714
    Z2=0.0                                              00002715
    Z3=0.0                                              00002716
    Z4=0.0                                              00002717
    Z5=0.0                                              00002718
    Z6=0.0                                              00002719
    PAGING=0                                            00002720
FORM SECTION (CRP)                                      00002730

FORM LINE WHEN PAGING                                   00002740
    H1=1                                                00002750
FORM LINE WHEN PAGING                                   00002760
    H50=TABLE 1 - NET INCOME BY CROP AND YEAR           00002770
FORM LINE WHEN PAGING                                   00002780
     V6.=T,HTITLE                                       00002790
FORM LINE WHEN PAGING                                   00002800
    V103.=T,OSDATE                                      00002810
FORM LINE WHEN PAGING                                   00002820
    H66=PERIOD                                          00002830
FORM LINE WHEN PAGING                                   00002840
    H5=CROP ACTIVITY                                    00002850
    D33 + 7(YR)=(YR)M                                   00002860
    H,L + 7=TOTAL                                       00002870
FORM LINE WHEN PAGING                                   00002880
    H5=------------                                     00002890
    H33 + 7(YR)=------------                            00002900
    PAGING=7                                            00002910
FORM LINE                                               00002920
    D5=(CRP)                                            00002930
```

```
      FORM LINE
          H6=EXPECTED NET INCOME                                        00002940
          H33 + 7(YR)=-                                                 00002950
          H,L + 9=-                                                     00002960
          ENI(CRP)=X,(CRP)*(TABLE EY(INCOME,(CRP))-TABLE COST           00002970
              (MCST,(CRP)) - TABLE INSUR(COST50,(CRP)))                 00002980
K          V34, + 7(YR)=N,ENI(CRP)                                      00002990
K          V,L + 10,TENI(CRP)=10 * N,ENI(CRP)                           00003000
      FORM LINE                                                         00003010
          H6=ADJUSTED NET INCOME                                        00003020
          H33 + 7(YR)=-                                                 00003030
          H,L + 9=-                                                     00003040
K         V34,+7(YR),ANI(YR)(CRP)=X,(CRP)*(TABLE AY((YR),(CRP))-        00003050
              TABLE COST(MCST,(CRP))- TABLE INSUR(COST50,(CRP)))        00003060
K          V,L + 10,TANI(CRP)=SUM(YR)(N,ANI(YR)(CRP))                   00003070
      FORM SECTION(YR)                                                  00003080
      FORM LINE                                                         00003081
K         II(YR)(CRP)=X,(CRP)*(TABLE MY(MINYLD,(CRP))-                  00003082
              TABLE AY((YR),(CRP)))                                     00003083
          TESTVAR=N,II(YR)(CRP)                                         00003084
      COPY                                                              00003085
LOGIC,IF N,TESTVAR GE 0.0 GO TO 400                                     00003086
      FORM LINE                                                         00003087
          II(YR)(CRP)=0.0                                               00003088
      COPY                                                              00003089
LOGIC,400                                                               00003090
      FORM SECTION,END                                                  00003091
      FORM LINE                                                         00003093
          H6=INSURANCE INDEMNITY                                        00003095
          H33+7(YR)=-                                                   00003100
          H,L+10=-                                                      00003110
          V34,+7(YR)=N,II(YR)(CRP)                                      0000312
          V,L + 10,TII(CRP)=SUM(YR)(N,II(YR)(CRP))                      00003130
      FORM LINE                                                         00003160
          H6=NET INCOME                                                 00003170
          H33 + 7(YR)=-                                                 00003180
          H,L + 9=-                                                     00003190
K         V34,+7(YR),NI(YR)(CRP)=N,II(YR)(CRP)+N,ANI(YR)(CRP)           00003200
K          V,L + 10,TNI(CRP)=SUM(YR)(N,NI(YR)(CRP))                     00003210
          PAGING=-1                                                     00003230
      SPACE                                                             00003240
      FORM SECTION,END                                                  00003250
      FORM LINE                                                         00003260
          H5=TOTAL FOR ALL CROP ACTIVITIES                              00003270
      FORM LINE                                                         00003280
          H6=EXPECTED NET INCOME                                        00003290
K          V34,+7(YR)=SUM(CRP)(N,ENI(CRP))                              00003300
K          V,L+10=SUM(CRP)(N,TENI(CRP))                                 00003310
      FORM LINE                                                         00003320
          H6=ADJUSTED NET INCOME                                        00003330
K          V34,+7(YR)=SUM(CRP)(N,ANI(YR)(CRP))                          00003340
K          V,L+10=SUM(CRP)(N,TANI(CRP))                                 00003350
      FORM LINE                                                         00003360
          H6=INSURANCE INDEMNITY                                        00003370
K          V34,+7(YR)=SUM(CRP)(N,II(YR)(CRP))                           00003380
K          V,L+10=SUM(CRP)(N,TII(CRP))                                  00003390
                                                                        00003400
```

```
      FORM LINE
          H6=NET INCOME                                                 00003410
K           V34.+7(YR)=SUM(CRP)(N,NI(YR)(CRP))                          00003420
K          V,L+10=SUM(CRP)(N,TNI(CRP))                                  00003430
      FORM LINE                                                         00003440
          PAGING=0                                                      00003441
      FORM LINE                                                         00003442
          H1=1                                                          00003443
          H47=TABLE 2 - TOTAL NET INCOME                                00003444
      FORM LINE                                                         00003445
          V6.=T,MTITLE                                                  00003446
      FORM LINE                                                         00003447
          V89.=T,OSDATE                                                 00003448
      FORM LINE                                                         00003449
          H55=TECHNOLOGY                                                00003450
      FORM LINE                                                         00003451
          H5=CROP ACTIVITY                                              00003452
          D33+14(B)=(B)M                                                00003453
          H,L+9=TOTAL CROP                                              00003454
      FORM LINE                                                         00003455
          H5=------------
          H33+14(B)=--------------------------------
      SPACE
      FORM LINE                                                         00003459
          H5=BEANS                                                      00003460
          V34.,W1=N,TNIB11+N,TNIB12                                     00003461
          V48.,Y1=N,TNIB21                                              00003462
          V92.,T1=N,W1+N,Y1                                             00003463
      SPACE                                                             00003464
      FORM LINE                                                         00003465
          H5=CORN                                                       00003466
          V34.,W2=N,TNIC11+N,TNIC12+N,TNIC13                            00003467
          V48.,Y2=N,TNIC21+N,TNIC22+N,TNIC23+N,TNIC24                   00003468
          V76.,Z2=N,TNIC41+N,TNIC42+N,TNIC43                            00003469
          V92.,T2=N,W2+N,Y2+N,Z2                                        00003470
      SPACE                                                             00003471
      FORM LINE                                                         00003472
          H5=CORN/BEANS                                                 00003473
          V34.,W3=N,TNIN11+N,TNIN12                                     00003474
          V48.,Y3=N,TNIN21+N,TNIN22+N,TNIN23                            00003475
          V92.,T3=N,W3+N,Y3                                             00003476
      SPACE                                                             00003477
      FORM LINE                                                         00003478
          H5=GARLIC                                                     00003479
          V48.,Y4=N,TNIG21+N,TNIG22                                     00003480
          V92.,T4=N,Y4                                                  00003481
      SPACE                                                             00003482
      FORM LINE                                                         00003483
          H5=POTATOES                                                   00003484
          V34.,W5=N,TNIP11                                              00003485
          V48.,Y5=N,TNIP21+N,TNIP22+N,TNIP23                            00003486
          V92.,T5=N,W5+N,Y5                                             00003487
      SPACE                                                             00003488
      FORM LINE                                                         00003489
          H5=WHEAT                                                      00003490
          V34.,W6=N,TNIW11                                              00003491
                                                                        00003492
```

```
     V48..Y6=N,TNIW21+N,TNIW22+N,TNIW23+N,TNIW24                    00003493
     V76..Z6=N,TNIW41+N,TNIW42+N,TNIW43+N,TNIW44                    00003494
     V92..T6=N,W6+N,Y6+N,Z6                                         00003495
SPACE                                                               00003496
FORM LINE                                                           00003497
     H5=TOTAL                                                       00003498
     V34.=N,W1+N,W2+N,W3+N,W4+N,W5+N,W6                              00003499
     V48.=N,Y1+N,Y2+N,Y3+N,Y5+N,Y6+N,Y4
     V76.=N,Z1+N,Z2+N,Z3+N,Z4+N,Z5+N,Z6                             00003501
     V92.=N,T1+N,T2+N,T3+N,T4+N,T5+N,T6                             00003502
COPY                                                                00003503
                                                                    00003504
END                                                                 00003505


     0004000   SIZE DICTDATA,DEC   0001684   MAX TABLE SIZE,DEC          0007885  REPORT RECORDS


                                                                          0000145  COMPILER BLOCKS
PILE                                                                00003506   TIME   REAL 00104105   TASK 00100127
```