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THE ROLE OF CROP CREDIT INSURANCE IN THE AGRICULTURAL CREDIT SYSTEM IN DEVELOPING ECONOMIES

by

ANDREW JAMES HOGAN

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THE ROLE OF CROP CREDIT INSURANCE IN THE AGRICULTURAL CREDIT SYSTEM IN DEVELOPING ECONOMIES

A thesis submitted to the Graduate School of the University of Wisconsin-Madison in partial fulfillment of the requirements for the degree of Doctor of Philosophy

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Dedication:

To Peter

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TABLE OF CONTENTS

DEDICATION ii

ACKNOWLEDGMENTS iii

LIST OF TABLES ix

LIST OF FIGURES x

CHAPTER I: INTRODUCTION 1

Background on Agricultural Credit and Economic Development 3

Crop Credit Insurance: The State of the Art . . 6

Significance of the Research 12

CHAPTER 2: THE ECONOMIC STATICS OF CROP CREDIT INSURANCE 13

Introduction 13

Risk and the Financing of Crop Production 14

A Simple Model of Farm Financial Risk 17

Crop Insurance 22

Crop Credit Insurance and Financial Risk 28

Compulsory Insurance and Non-Risk Averse Decision Making 45

Alternatives to Crop Insurance - Diversification and Share Contracts 48

CHAPTER 3: CROP CREDIT INSURANCE IN A DYNAMIC SETTING 59

Introduction 59

Background on Temporal Risk 59

A Simple Intertemporal Model of Income Risk . . . 62

A Simple Intertemporal Model of Capital Risk . . . 69

Alternatives to Crop Insurance - Forced Savings and Forecasting 73

Crop Credit Insurance and Technical Change in a Dynamic Setting 83

The Impact of Insurance on the Supply of Credit . 90

Conclusions 100

CHAPTER 4: AN INSTITUTIONAL ANALYSIS OF CROP CREDIT INSURANCE IN THE AGRICULTURAL CREDIT SYSTEM 101

Introduction 101

A Reformulation of the Crop Credit Insurance Model 102

The Systems Perspective and Crop Credit Insurance 110

Crop Insurance in the Agricultural Credit System 111

A General Model of the Agricultural Credit System 114

The Case of Mexico 118

1. Institutional Structure for Subsidizing Agricultural Credit in Mexico 119

2. Mexican Agricultural Credit: A System Perspective 123

3. The Social Functions of Crop Credit Insurance 129

4. Consequences of the Lack of Managerial Control 144

5. Agricultural Credit, Insurance and SAM 146

The Case of Panama 148

1. The Institutional Structure for Subsidizing Agricultural Credit in Panama 149

2. Panamanian Agricultural Credit: Some General Considerations 157

Methodological Note 160

CHAPTER 5: GUIDELINES FOR THE EMPIRICAL EVALUATION OF CROP CREDIT INSURANCE 162

Introduction 162

Major Empirical Issues 162

Problems of Generalization 168

Coordination of Price Stabilization and Crop Credit Insurance Programs 178

Models for Empirical Research 182

Conclusions 198

CHAPTER 6: SUMMARY AND CONCLUSIONS 200

APPENDIX 209

BIBLIOGRAPHY 212

LIST OF TABLES

TABLE IV-1 132
TABLE IV-2 135
TABLE IV-3 136
TABLE IV-4 140
TABLE IV-5 154

LIST OF FIGURES

FIGURE II-1 29
FIGURE II-2 32
FIGURE II-3 34
FIGURE II-4 35
FIGURE II-5 38
FIGURE II-6 47
FIGURE II-7 50
FIGURE II-8 52
FIGURE II-9 54

FIGURE III-1 63
FIGURE III-2 66
FIGURE III-3 70
FIGURE III-4 77
FIGURE III-5 85
FIGURE III-6 97

FIGURE IV-1 107
FIGURE IV-2 115
FIGURE IV-3 124

FIGURE V-1 165
FIGURE V-2 172
FIGURE V-3 179

CHAPTER 1

INTRODUCTION

Why do small farmer oriented agricultural credit programs so often go bankrupt in developing economies? Even where interest rates are heavily subsidized and the agricultural technology to be financed by the loan has been proven effective, why are small farmers so reluctant to participate in agricultural credit programs? Lastly, what can be done to improve both the financial viability of agricultural credit programs and the participation of small farmers in these programs?

Crop credit insurance has been proposed as a possible answer to the last question. In this thesis, my first task will be to lay out the conceptual framework for analyzing crop credit insurance. First, I will adapt and extend an existing microeconomic model of insurance to analyze the effect of crop credit insurance at the farm level. Second, I will look at the effect of crop credit insurance on the credit program, specifically on the problem of defaults. Third, I will develop a qualitative systems model of an agricultural credit system in a developing country. This model will allow me to relate the farm level model and the credit program model into a broader institutional framework where economic, social and political considerations are

brought into play. This systems model will be used to analyze the crop credit insurance institutions in Mexico and Panama.

My next task will be to specify the conceptual and empirical issues which need to be addressed in evaluating crop credit insurance programs. On the conceptual level, I will discuss the implications of evaluation crop insurance in economies whose structures differ in important ways from that of the perfectly competitive market economy of static neoclassical economic theory. I will also discuss the state of the empirical research on crop credit insurance and suggest where existing empirical models might be improved.

This research is first and principally an effort to develop an adequate conceptual framework for the economic analysis of crop credit insurance research. In this, I will employ concepts and models developed in the area of finance economics, specifically as relates to insurance, credit and decision making under risk. Unfortunately, it will be shown that the standard results derived from economic theory are often inappropriate in the analysis of real-world crop credit insurance programs because of a variety of institutional interventions and market imperfections. In the spirit of the theory of the Second Best, I will undertake to describe the economic system in which

crop credit insurance programs must operate using techniques developed in the field of qualitative systems analysis. The last part of the thesis, which considers the question of how to evaluate existing insurance programs, will be developed from the perspective of social cost-benefit analysis.

Background on Agricultural Credit and Economic Development

Programs designed to improve the income levels of small farmers emphasize the need to increase the use of new agricultural production technology (Schultz 1964; Lipton 1979; Scrimshaw and Taylor 1980). New technology will increase the marginal product of labor, allowing the farm family to enjoy a greater income. Technological change in agriculture, sometimes called the Green Revolution, brought with it a host of new problems; principal among these were erratic supply of the new, purchased inputs, marketing problems with the product and differential rates of adoption among different classes of farmers, exacerbating already pronounced income distribution problems (Thiesenhusen 1972). It was noticed that larger and richer farmers were better able to take advantage of the new technology than were smaller farmers. This phenomenon often led to the displacement of labor through excessive mechanization (Gotsch 1973).

Apart from better education and better managerial practices, large farmers had better access to agricultural extension services and adequate credit to finance the purchase of new technology (Donald 1976). Current agricultural development theory conventionally emphasizes the need for agricultural credit programs to facilitate the adoption of new technology in order that greater income disparities be avoided (Thornton 1973; Chenery, et al. 1974, Chp. 6; Lipton 1979; Mellor 1976, Chp. 4). However, it soon became apparent that credit programs for small farmers were encountering some very serious difficulties; among them were high per unit administrative costs and high rates of loan default (Bottomley 1975; Donald 1976). Small farmer credit schemes were regularly going bankrupt due to the twin squeeze of default and administration on operating capital. The burden of administration was to be lightened through the use of credit cooperatives as financial intermediaries; this effort has met with mixed success. The problem of loan defaults led to the idea of insuring the loan, which, in turn, required the creation of crop credit insurance programs. These programs are the subject of this thesis.

Finance is one of the most highly developed areas of economic science both in its theoretical foundations and

practical application. It has long been recognized in the finance literature that the financial structure of the firm (the way in which productive assets are owned and how these forms of ownership influence the distribution of income) has a significant impact on the decision of the firm to borrow. For some reason these concepts and experience have never been brought to bear in the analysis of small farmer borrowing behavior. It is common knowledge that poor farmers are reluctant to go heavily into debt in order to purchase new production technology which promises high expected returns. We will show here that recourse to explanations of innate backwardness or "culture of poverty" are unnecessary to understand farmer behavior, but rather that conventional credit programs magnify the objective riskiness of adoption through adverse changes in the financial structure of the small farm enterprise. When small farmers adopt new technology financed through conventional credit programs, high default rates are to be expected, leading to the gradual decapitalization of the program. Even with high default rates, farmer participation in these programs may not be adequate. It will be shown that crop credit insurance may alleviate these problems. Some mention will also be made of the role of price stabilization, alone or in combination with crop

insurance, in mitigating the problem of default, thereby influencing the financial viability of credit programs.

Crop Credit Insurance: The State of the Art

In a comprehensive analysis of the experience of crop insurance programs worldwide, Crawford (1977) found significant crop insurance programs in the United States, Japan and Sweden, and among the developing countries in Mexico, Sri Lanka, Brazil, Costa Rica, Kenya, Mauritius and India. Since his review, one more significant program has emerged in Panama, and programs are commencing in Bolivia and Ecuador. I will not attempt to repeat Crawford's excellent review here. Suffice it to say that while several crop insurance programs are firmly established (e.g., U.S., Japan, Sweden and Mexico), others such as Sri Lanka and Costa Rica are widely recognized as failures and still others like Brazil and India have been discontinued. Of the "successful" programs, only the U.S. crop insurance program operates without heavy government subsidization, and this was achieved after more than ten years of heavy losses and several bankruptcies. Thus, it is fair to say that the question of the viability of crop insurance programs has not been entirely answered. Crop insurance as a development policy, as opposed to a subsidy-income maintenance policy, has clearly not been established to date.

The microeconomics of crop insurance have never been systematically studied; most of the economic analyses which seem applicable has been developed within the framework of making production decisions under risk and uncertainty, and no account has been taken of the financial structure of the production unit. Even more scarce is analysis of the macroeconomic impact of insurance on agricultural product prices, consumers' and producers' surpluses (Hazell and Pomareda 1980). Lastly, systematic analyses of crop insurance programs and related institutions are virtually non-existent.

In 1978, the Agency for International Development provided approximately four million dollars to the Inter-american Institute of Agricultural Sciences (IICA) to set up a Crop Credit Insurance Research Project. The purpose of the research program was to make an extensive analysis of the crop insurance program in Mexico, provide technical support for the incipient program in Panama, and to promote and support crop insurance programs in Ecuador and Bolivia (USAID 1978). The Crop Credit Insurance Research Program was located administratively in the central offices of IICA in San Jose, Costa Rica, which allowed for limited research on the Costa Rica crop insurance programs.

To date, four areas of research have been undertaken. First, a financial and institutional analysis of the

Mexican crop insurance program was conducted by the author and his thesis advisor, Prof. Robert Aubey. Some additional analysis was performed by the author on the Panamanian program. The most important results of these analyses are reported in Chapter 4. Second, a mathematical programming model of small farmer decision making was developed by Peter Hazell of the International Food Policy Research Institute. The original model was tested with data based on a survey of Guatemalan small farmers. Later the model was modified with the help of the author and was retested first with data from Mexico and later with data from Panama. Unfortunately, in none of these countries is data available on the variability of yields and prices to individual farmers over time. Thus, the estimation of risk was based entirely on reasonable but fabricated data. The results of these exercises will be published in Hazell and Hogan (in preparation). Meanwhile, data collection activities have begun in Panama, where it is hoped that an adequate data base will be available within three years. The modelling exercises produced a number of interesting results: risk-neutral farmers are indifferent to insurance under some conditions but will actually choose insurance under other circumstances. Chapters 2 and 3 will develop the theoretical framework to understand these results.

Third, research has been undertaken to incorporate the effects of crop credit insurance into existing macroeconomic planning models (Hazell and Pomareda 1980). To date this has only been undertaken for the trade model of Central America. Working with the entire model was found to be impractical, and the Guatemalan sub-model was broken out and analyzed. The results, while positive, are diminished somewhat by the fact that Guatemala does not have a crop insurance program, making verification difficult. Some limited sectoral analysis was performed on the data the author assembled from Mexico, but again this is not an empirical test. Some reference will be made to the sectoral effects of crop insurance in the concluding remarks in Chapter 5.

Fourth, research has been undertaken to develop actuarial practices and planning models for the crop insurance programs. Actuaries have been brought in to assist in the improvement of actuarial data collection and estimations. Also a portfolio model was developed by the author to assist in planning of coverage levels and premium rates in Panama (Arcia and Hogan 1981). In Chapter 4, the actual practice of premium rate determination will be discussed in some detail.

Although a significant number of studies of a conceptual and empirical nature on some kinds of publically

sponsored insurance have been performed, particularly health insurance, very little work has been done in the area of crop insurance. The work of P.K. Ray (1969), the so-called father of crop insurance, has been of a largely descriptive nature and makes little reference to the effect of crop insurance on the financial structure of the farm enterprise. Likewise, Maurice (1977) and Crawford (1977) only summarize general results from insurance and economic theory without dealing with any of the financial components of the problem.

Perhaps the best known analysis to date is the work of Roumasset (1976) which develops a case against crop insurance. Much of Roumasset's article deals with practical and institutional considerations of implementing crop insurance programs. While some of these observations are very insightful, they are not based on any direct experience with crop credit insurance programs. These are not the focus of this thesis and will be ignored here.

Of a more fundamental nature, Roumasset claims that crop insurance can lead to the misallocation of resources in agriculture. First, he claims that most farmers are no risk averse and therefore will not accept crop insurance willingly. If there were a significant demand for crop insurance, it would be met by private sector institutions. Since there is no reason why the government should have a

comparative advantage in administrating a crop insurance program, the creation of such a program will be a misallocation of public funds. Second, if crop insurance is made compulsory to guarantee a sufficiently large clientele to make the scheme work administratively and actuarially, then resource misallocation will take place at the farm level. Persons who would not willingly purchase insurance (risk neutral and risk taking individuals) will, under the compulsion to consume insurance, act in ways to justify its need; they will take on more risks in order to re-achieve the level of riskiness which they enjoyed before they were compelled to accept the insurance. The pattern of resource allocation which would result after these maneuvers may well be less optimal than the pattern which existed before the introduction of the insurance. In Chapter 2, we will show that the second of these arguments is partly illogical and partly incorrect. In Chapter 4, the first argument will be shown to be correct but based on such narrow premises that it is of little value in the evaluation of existing programs. Instead, a much broader systems framework is developed to study crop credit insurance as a component of a wider agricultural credit system.

Significance of the Research

This research adds significantly to the fund of descriptive knowledge on the institutional environment in which crop credit insurance programs must function. It clarifies how crop credit insurance programs relate to, condition and are conditioned by other institutions within the agricultural credit system. The lack of this kind of a framework has led both critics and proponents of crop insurance to make false assumptions about the role of crop insurance and to mistakenly estimate the costs and benefits of such programs.

In addition to developing a more adequate conceptual framework for the analysis of crop insurance, I will indicate some of the issues which must be dealt with in the forthcoming empirical research, if an adequate evaluation of crop credit insurance is to be made. In the course of this analysis, some questions about the validity and generality of some standard models in finance economics will be raised and explored.

CHAPTER 2

THE ECONOMIC STATICS OF CROP CREDIT INSURANCE

Introduction

Static economic models of insurance will be adapted here to the special case of crop credit insurance. In order to understand the potential beneficial effects of insurance linked to credit, we first need to develop a model of the financial structure of the agricultural enterprise. We will see that crop credit insurance can be used to offset the well-known risk magnifying effects of increasing the debt/equity ratio of an enterprise. It will be made clear that even mildly risk averse decision makers can reasonably be expected to balk at the adoption of new production technology if that adoption involves a significant increase in the debt/equity ratio.

We will then discuss crop insurance in general terms and distinguish crop credit insurance from other types of insurance used in agriculture. Certain specific features of crop credit insurance will be discussed.

Next, we will develop a model of decision making under risk in which we can examine the way in which crop credit insurance will affect the farmer's decision to borrow funds from an agricultural credit program. Often this decision involves the adoption of new production technology.

Lastly, we will discuss two alternatives to crop insurance: crop diversification and share rent contracts. We will point out the conditions under which either of these risk management mechanisms might make crop credit insurance superfluous.

Risk and the Financing of Crop Production

It is convenient to classify the sources of risk in crop production as natural risk and market risk. Natural risk arises from the variability of physical production due to factors beyond the farmer's control, such as weather, pests and disease. Market risk arises from the variability of the unit price which the farmer receives for the crop. These two factors combine to produce a variable gross revenue stream. This gross revenue stream will be more or less variable than its constituents according to the nature of the correlation between physical yields and prices: a positive correlation will produce a gross revenu stream more variable than the yield or price stream; a negative correlation a gross revenue stream less variable.

We will now lay some groundwork for our analysis of income stabilization policies in agriculture and how they affect the way in which the prices and the supplies of products covary. (See Hazell and Scandizzo 1975, 1977 for a recent discussion). If agricultural markets are closed

to imports, the tendency is that prices and supplies (in this case marketed yields) of a product will covary negatively -- prices are up when yields are down, and prices are down when yields are up. If the market is opened to exports, then the negative correlation between prices and yields may no longer hold -- total supply may now be more or less than total yield. Political and/or broader economic considerations can now have a significant impact, in as much as food importation policy is often not designed to produce international market equilibrium. These factors can change either the price of an agricultural product or its supply or both.

To see the impact of this on the financial risk faced by the farmer, let us assume that the variance in the gross revenue R is the legitimate measure of variability and suppose that $R = P \cdot Y$, where P is the price of the product, and Y is the yield. Adapting the formula for the variance of a ratio (Cochran, 1977, p. 153)

$$\mathrm{Var}(R) \doteq 1/P^2 \; (S_y^2 + R^2 S_p^2 + 2R\rho S_y^2 S_p^2) \qquad (1)$$

where

$R = E(P) \cdot E(Y)$

S_y^2 = variance of yields

S_p^2 = variance of prices

ρ = correlation of yields and prices

Suppose we have a closed market where the price and yield of a product are negatively correlated. If price stabilization were introduced, the same price would prevail across all states of nature regardless of the level of yield. In other words, the correlation coefficient and S_p would become zero. The effect of this is to cause the first and third terms in (1) to vanish. If the sum of those two terms were negative, then the overall variance is likely to increase. (It is only likely because (1) is an approximate formula unable to incorporate the changes in the mean of the product which are caused by a change in the series of one of its components.)

Now if we leave price stabilization and introduce insurance, the effect is to stabilize physical output, which causes the second and third terms of (1) to vanish. Again it is possible that yield stabilization by itself could actually increase the variance of gross revenue, were yields and prices naturally highly negatively correlated. On the other hand, if yields and prices are positively correlated, a reduction in variance is likely to be forthcoming from either kind of stabilization policy

In the discussion to be developed in this and succeeding chapters, we will assume that crop credit insurance is being employed under circumstances where it can actually reduce, not increase, the variability of gross revenue for the typical farmer. Most of the countries which have or plan to implement crop credit insurance also have or aspire to have price stabilization programs. Under such conditions, it is sufficient to minimize yield variability to reduce the riskiness of gross revenues at the farm level. This does not prove, however, that price stabilization is a good idea, and certainly it cannot be justified solely on the grounds that it makes crop credit insurance conceptually tractable. In conclusion, then, the reader is forewarned that even the most favorably conceived and implemented crop credit insurance program may not be appropriate under all conditions.

A Simple Model of Farm Financial Risk

Consider now a simple model of farm income:

$$Y = r(Q + L) \tag{2}$$

where

Y is gross income,

Q is equity,

L is debt, and

r is the rate of return on investment.

If the producer borrows to finance production, interest must be paid on the loan. Thus, net income becomes:

$$I = Y - iL = r(Q + L) - iL \ , \tag{3}$$

where

I is net income (a random variable) and

i is the interest rate on debt.

Since both equity (Q) and debt (L) are committed to the production process before the uncertain future is known and since the interest rate (i) is set by contract, all of the variability in the gross income falls on the equity-holder. Using, for example, the variance as a measure of variability, we see:

$$Var(I) = Var(Y - iL) = Var(Y) = (Q + L)^2 Var(r). \tag{4}$$

Thus, holding assets constant, an increase in the debt/equity ratio will increase the overall riskiness of the income stream. To see this, let the coefficient of variation of income measure the relative riskiness of the income stream, where $CV(I) = \sigma_I/E(I)$, σ_I being the standard deviation of income and $E(I)$ the expected income. Let

$\delta = L/Q$, the debt/equity ratio. Since total assets A are fixed, the debt/equity ratio becomes $\delta = L/Q = (A-Q)/Q = (A/Q)-1$. Substituting δ into the formulas for expected income and the standard deviation of income, we have:

$$E(I) = Q(r(1+\delta)-i\delta) \quad \text{and} \quad \sigma_I = (Q+L)\sigma_r = Q(1+\delta)\sigma_r \,, \tag{5}$$

where

σ_r is the standard deviation of the rate of return on investment.

Given that total assets are fixed, an increase in debt will decrease expected net income:

$$\frac{dE(I)}{d\delta} = \frac{\partial E(I)}{\partial Q}\frac{dQ}{d\delta} + \frac{\partial E(I)}{\partial \delta} = E(r)\,(r(1+\delta)-i\delta)\frac{dQ}{d\delta} + Q(E(r)-i) \tag{6}$$

Since $dQ/d\delta = -A/(1+\delta)^2 = -(Q+L)/(1+\delta)^2$, (6) becomes:

$$\frac{dE(I)}{d\delta} = -\frac{(E(r)(1+\delta)-i\delta)(Q+L)}{(1+\delta)^2} + (E(r)-i)Q = -i\frac{Q}{1+\delta} < 0. \tag{7}$$

Given fixed total assets, there is no change in the variance of net income given an increase in the level of the debt/equity ratio:

$$\frac{\partial \operatorname{Var}(I)}{\partial \delta} = \frac{\partial Q(1+\delta)\operatorname{Var}(r)}{\partial \delta} = \operatorname{Var}(r)\,(Q + (1+\delta)\frac{dQ}{d\delta}) = \tag{8}$$

$$\operatorname{Var}(r)\,(Q + (1+\delta)\frac{-A}{(1+\delta)}) = \operatorname{Var}(r)\,(Q - \frac{Q+L}{1+\delta}) = \operatorname{Var}(r)\cdot(0) = 0 \,,$$

since $Q + L = Q(1+\delta)$. Thus, the change in the coefficient of variation of income with respect to the change in the debt/equity ration where total assets are fixed becomes:

$$\frac{\partial CV(I)}{\partial \delta} = \frac{\partial \sigma_I / E(I)}{\partial \delta} = \frac{E(I)\partial \sigma_I / \partial \delta \; - \; \sigma_I \cdot \partial E(I)/\partial \delta}{E(I)^2} =$$

$$\frac{E(I)\cdot(0) \; - \; (Q+L)\sigma_r(-iQ/(1+\delta))}{E(I)^2} = \frac{\sigma_r iQ^2}{E(I)^2} > 0 . \qquad (9)$$

Thus, the riskiness of the income stream, as measured here by the coefficient of variation, increases as the debt/equity ratio increases.

The more realistic situation, however, is one in which the level of investment and the debt/equity ratio increase. The typical scenario is one in which the producer's equity remains roughly constant while the level of external investment is increased through publically sponsored credit programs. In this case, the effect of increasing debt on the relative riskiness of the producer's income stream is similar but lessened when compared to the results of (9). Given that total investment is allowed to grow, we differentiate the expected income and the standard deviation of income (5) with respect to debt:

$$\partial E(I)/\partial L = E(r) - i > 0 \quad \text{and} \qquad (10)$$

$$\partial\sigma_I/\partial L = \sigma_r > 0 \tag{11}$$

Thus, while the variability of net income increases as debt increases (equity held constant, implying a greater debt/equity ratio), the level of expected net income also increases. Letting the coefficient of variation again measure the relative riskiness of the resulting income stream, we see that increasing the level of debt leads to greater riskiness:

$$\frac{\partial CV(I)}{\partial L} = \frac{E(I)\partial\sigma_I/\partial L - \sigma_I\partial E(I)/\partial L}{E(I)^2} =$$

$$\frac{E(I)\sigma_r - (E(r) - i)\sigma_I}{E(I)^2} = iQ\sigma_r/E(I)^2 > 0. \tag{12}$$

While the increase in the coefficient of variation is reduced, in this case ($iQ\sigma_r/E(I)^2$ versus $iQ^2\sigma_r/E(I)^2$, where total assets are allowed to increase by the increase in the level of debt, the effect is much the same -- an increment in the debt/equity ratio will increase the relative riskiness of the resulting income stream.

Obviously, a risk neutral producer (one insensitive to income variability) will always choose higher levels of debt as long as $E(r) > i$. A mildly risk averse producer might do the same, except that large changes in debt will

greatly increase the relative variability of income. Therefore, poor farmers might well behave in a virtually profit maximizing (risk neutral) fashion under normal conditions, but may begin to act in a pronouncedly risk averse fashion when they are invited to participate in credit programs that will dramatically change the level of investment.

This kind of problem is most likely to arise where publically sponsored credit programs are directed toward marginal farmers with very unfavorable net asset positions. Typically these farmers have been difficult to incorporate into agricultural credit programs. It has been thought that their reluctance was based on "traditional" or "backward" attitudes toward innovation arising from a "culture of poverty" (Rogers, 1971). Clearly there is another explanation -- their very poverty often forces them to face objectively much greater risks than the middle income farmer because they must go so deeply into debt to adopt the basic technological package being promoted by the credit program. One means of reducing the risk magnifying effects of high indebtedness is to offer insurance on the investment, at least to the level of debt incurred.

Crop Insurance

Within the category of agricultural insurance, there is a variety of different types of insurance policies (see Ray,

1967 and Maurice, 1977). Here we will limit ourselves to insurance on annual crops. Insurance on multiyear crops or equipment is rare, although multiyear livestock insurance is available in Mexico and Panama. First, it should be noted that insurance policies are written to cover specified insurable risks. Most publically sponsored crop insurance programs offer "all-risk" insurance, although some public and many private insurance schemes offer specific (one-risk) or combined (several risk) policies (see Crawford, 1977 for more details). It is important to keep in mind that the payment of compensation must be preceded by a recognizable event which is related to the risk stipulations of the policy. Thus, even with "all-risk" insurance, some recognizable natural disaster (fire, hail, flood, wind, etc.) must occur; the insurance agency must be informed and acknowledge the existence of the event. If a farmer were to discover upon harvesting his/her crop that the yield was below the specified critical limit but could not point to a natural event which caused this decline, there would be no compensation payment. In the theoretical analysis which follows, we will ignore the cases of low production levels not being compensated, but it should be kept in mind that even a perfectly efficient all-risk crop insurance scheme

will not completely eliminate the consequences of variability in yield levels.

The other major question of interest in categorizing insurance schemes is the kind of coverage. Here we will make a distinction between a harvest insurance and a credit insurance on the basis of the different procedures for determining coverage. Harvest insurance covers loss up to the value of the expected harvest. Usually the unit price of the crop is specified in advance (although there are some exceptions) and a compensation payment will be made if yields fall below some specified percentage of the expected yield. The other major approach is crop credit insurance where the insurance coverage is limited to the amount loaned and the compensation payment cannot exceed the quantity loaned. Many credit programs loan farmers sufficient funds to cover all production costs, and the Panama program allows farmers to insure all production costs, even if they are partially self-financed. For simplicity, we will deal with the most general case where credit insurance covers all production costs, which for reasons of economic feasibility ought to be less than the value of the expected yield.

Obviously a major distinction between all-risk crop insurance and all-risk crop credit insurance is that the latter is provided only as part of a broader credit program and has as at least one of its goals the mitigation of the

risk magnifying effects of increasing the debt/equity ratio. Therefore, crop credit insurance must be evaluated in the context of the goals of the overall credit program and specifically in terms of the contribution which it makes to the functioning of the credit system. In Chapter 4, we will look at crop credit insurance as a component of a broader agricultural credit system. Here we will develop analytical models to investigate the impact of crop credit insurance on the farmer-debtor and on the lending institution. Before proceeding, we need to consider the principal characteristics common to all kinds of insurance contracts.

Consider the case of an insurance policy against some kind of crop loss. The insurance premium would be:

$$\theta = 1/N \sum_{s} \xi_s (1 + \phi + \mu) = E(\xi_s)(1 + \phi + \mu) \qquad (13)$$

where

θ is the premium to be paid in each of the N states of nature,

ξ is the compensation payment in state of nature s,

ϕ is the safety loading, and

μ is the administrative loading.

The safety loading ϕ is used to produce a reserve fund which will cover the losses of the insurance company in an unfavorable state of nature. In a perfect insurance world, the

company's portfolio of policies would be perfectly diversified; and therefore, premiums and compensation payments would cancel each other out across the states of nature. Most standard actuarial science is developed on the premise that the risk of loss among the policyholders is independent. In an area like crop insurance, this is hardly ever the case; drought, floods, hurricanes, etc. are likely to be widespread. Thus, if the insurance program is not to become bankrupt under some conditions, a reserve must be generated by adding a safety loading.

Most of the economic theory of insurance, like that of perfect markets, assumes that risk can be spread costlessly. In fact, administrative costs are often an important component of total costs and someone must pay them. An administrative loading is added to the premium for this reason. A premium is called actuarially fair if it is equal to the expected compensation payment. Most of the public crop insurance programs have as their goal to offer an actuarially fair premium. This means, of course, that subsidies are necessary to cover the administrative costs and to bail out the program in unfavorable states of nature. Here we will operate within the framework of an actuarially fair insurance, but it must be kept in mind that the social benefits of such a program will have to offset these additional costs.

The compensation payments made to the insured in the case of an unfavorable state of nature are affected by two stipulations in the insurance policy -- the deductible and coinsurance. Given an insurance scheme related to the average yield of a crop, the compensation payment in a state of nature s will be:

$$\xi_s = P_s \chi \max(\beta E(y) - y_s , 0) , \tag{14}$$

where

ξ_s is the compensation payment,

P_s is the price of the crop in state of nature s

y_s is the yield in state of nature s

$E(\cdot)$ is the expectation operator

χ is the coinsurance factor, $\chi > 0$

β is the deductible, $0 \leq \beta \leq 1$.

It may be thought strange that χ can be greater than one, but there is an experimental program in Mexico where $\chi = 1.4$. Under such circumstances, crop insurance is being used as a contingent transfer mechanism. A complete specification of the insurance premium identity is:

$$\theta = 1/N \Sigma P_s \chi \max(\beta E(y) - y_s, 0) \cdot (1 + \phi + \mu) \tag{15}$$

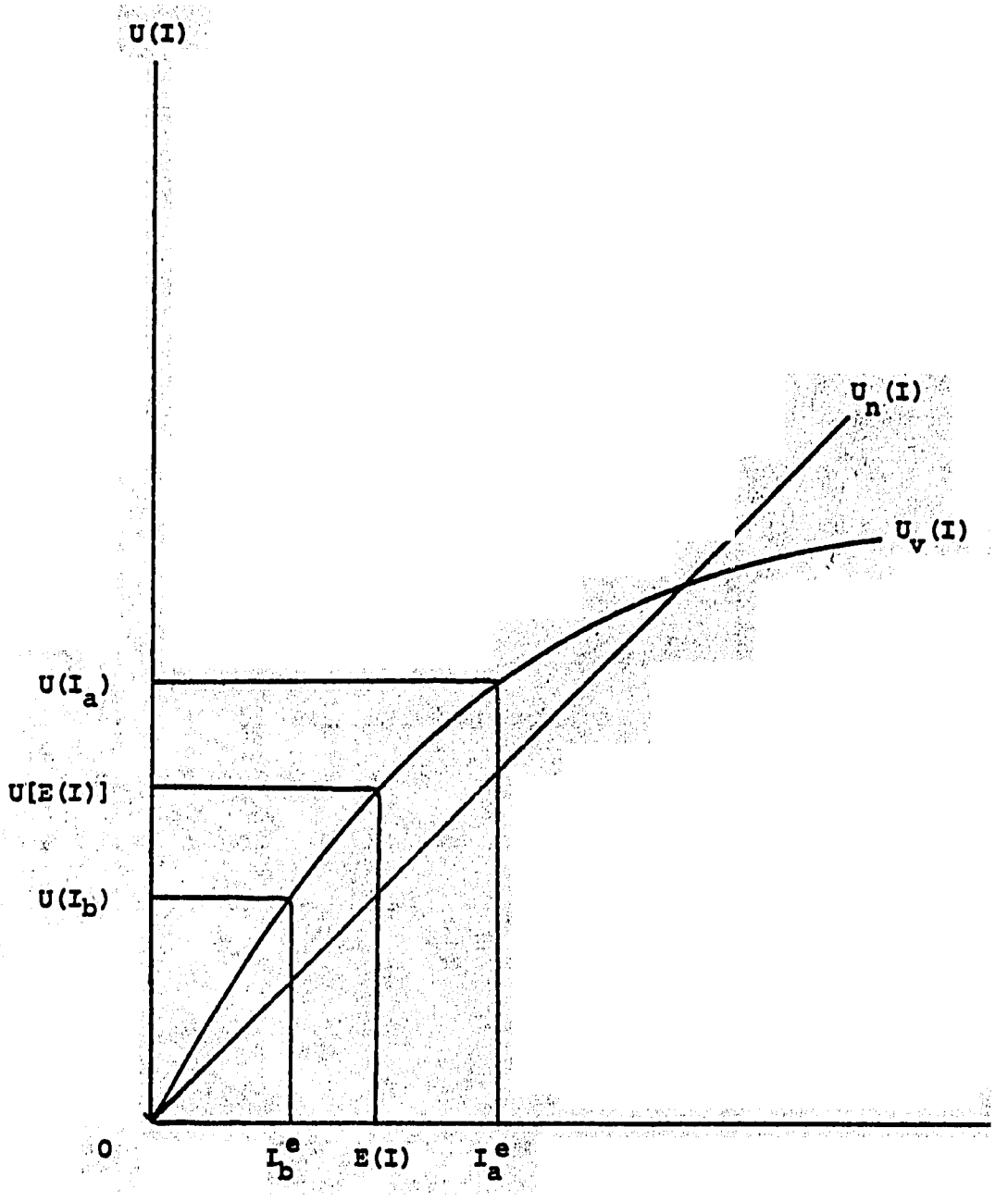
where in the case of an actuarially fair insurance, $\phi = \mu = 0$.

Crop Credit Insurance and Financial Risk

Let us begin our analysis with an exposition of the insurance model proposed by Ehrlich and Becker (1972). We will begin with a graphical analysis and then develop the mathematical model and apply it to the case of crop credit insurance. The Ehrlich-Becker model differs from the standard, first by using only one insurance variable, net compensation ($\xi_s - \theta$) in our earlier notation) rather than a premium and a compensation payment. This greatly facilitates the graphical analysis and will be employed here. Second, the Ehrlich-Becker model uses the states of nature framework (Malinvaud, 1972, Chp. 11) rather than the more conventional mean-variance framework. This is helpful because it allows us to avoid a prolonged discussion on the relative merits of the mean-variance model (Borch, 1969; Feldstein, 1969; Tobin, 1969; Roumasset, et al., 1979). Therefore, the ideas in this section will be developed within the states of nature framework.

In Figure II-1, we present the standard economic model of decision making under risk. On the horizontal axis, we have income and on the vertical axis, utility. We represent the utility function of the risk averse individual by $U_v(I)$ and the risk-neutral (profit-maximizing) utility function by $U_n(I)$. With the risk neutral individual, total utility

FIGURE II-1



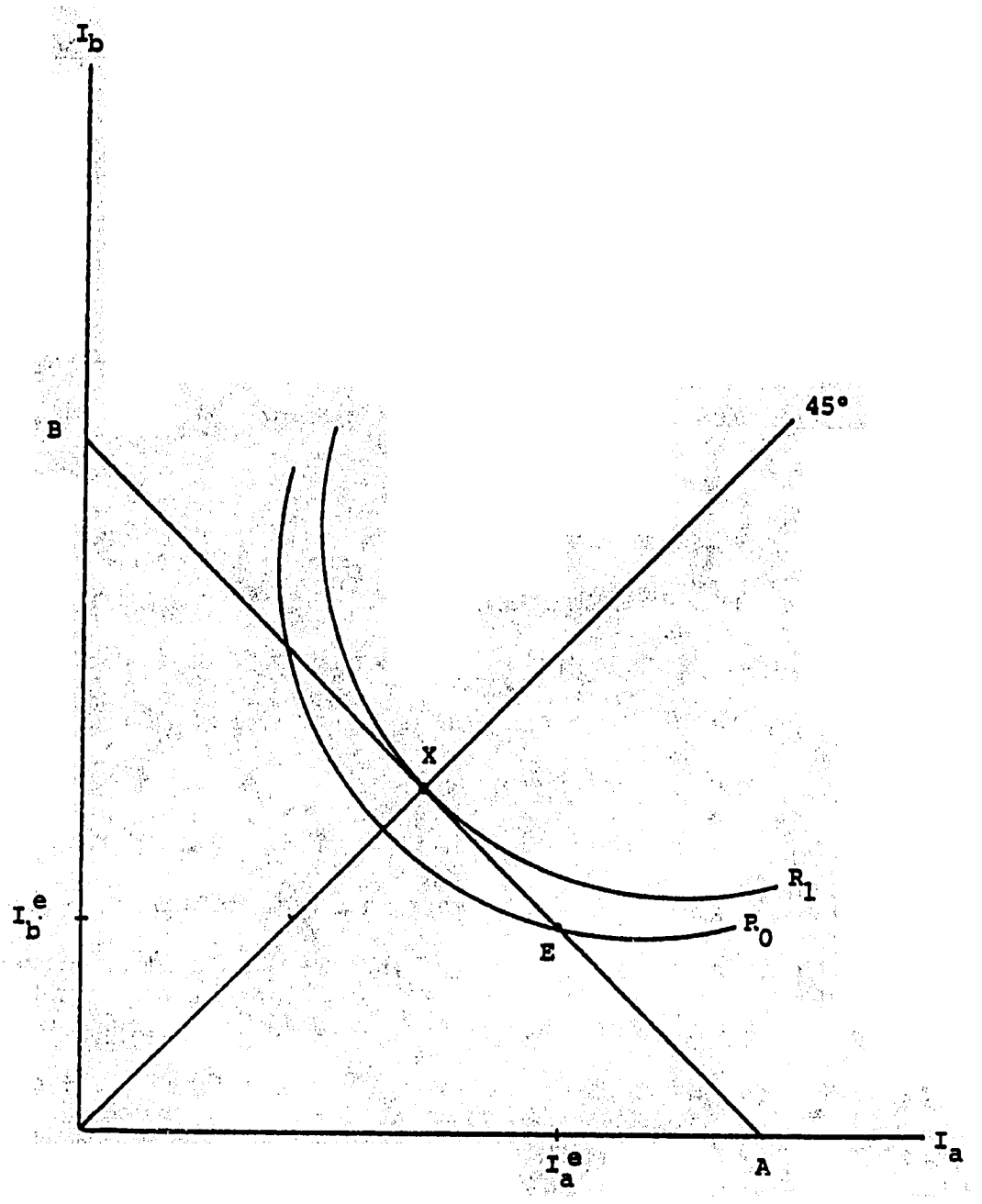
goes up as a constant (linear) function of income. The risk averse utility function is characterized by diminishing marginal utility of income ($U_v' > 0$, $U_v'' < 0$).

Consider a world in which there are two states of nature "a" and "b". When state "a" occurs, the resulting level of income is I_a^e. When "b" occurs, the individual enjoys income level I_b^e, where $I_b^e < I_a^e$. On the average, the individual enjoys $E(I) = pI_a^e + (1-p)I_b^e$, when p is the probability that state "a" occurs and (1-p) the probability that state "b" occurs.

For the risk averse individual, the variability in the income stream imposes a hardship. If state "a" occurs, utility level $U(I_a^e)$ is enjoyed; $U(I_b^e)$ is achieved if state "b" occurs. The level of expected utility is $E[U(I)] = pU(I_a^e) + (1-p)U(I_b^e)$. Consider the case where the individual could enjoy the expected income all of the time; the level of utility in the case is $U[E(I)]$. When we plot these results in Figure II-1, we discover that $U[E(I)] > E[U(I)]$ for the risk averse individual. Clearly, a mechanism which will guarantee the expected income in each state of nature will increase the level of satisfaction for the risk averse individual. For the risk neutral person, the reader can verify that the variability in income causes no hardship. For such an individual, $E[U(I)] = U[E(I)]$.

For the purpose of our analysis of insurance, we will want to reformulate Figure II-1. This reformation is presented in Figure II-2. Figure II-2 represents the simple insurance case. If state "a" occurs, the consumer has income I_a^e, and if state "b" occurs, income I_b^e. The line BA, drawn through point E, is the insurance line. It allows the consumer to transfer income across states of nature to any point on the line. If the slope of the line is equal to p/(1-p) (in the figures that follow, p/(1-p) = .5/.5 = 1), then the insurance line is the fair odds line, which means that the insurance is actuarially fair. The point where the fair odds line intersects the 45° ray is the expected value of the income endowment. Actuarially fair insurance with no deductible or coinsurance will smooth out the loss such that the consumer can enjoy the average income in all states of nature. With a risk averse individual, utility will always be optimized where income is as close to equal as possible across the states of nature. A risk neutral individual will have a series of indifference curves which are parallel to the fair odds line. By definition, the utility function of the risk neutral individual is linear in income and depends only on the expected value, not the variability across states of nature. Such an individual would be indifferent between points E and X in Figure II-2.

FIGURE II-2



In Figure II-2 where the risk averse decision maker has a utility function which produces the indifference curves like R_0 and R_1, the level of satisfaction can be improved by using insurance to redistribute income in order to reach point X. At point X, the decision maker achieves indifference curve R_1 which is greater than R_0 at point E.

In Figure II-3, we can see the effect of a deductible. Now the insurance line cannot be used to reach point X, but only point D on the deductible ray. The insurance is still actuarially fair, but the coverage level has been reduced by the amount of the deductible. In this case, the decision maker cannot reach indifference curve R_2 at point X but only R_1 at D, which is still an improvement over indifference curve R_0. In Figure II-4, we have the case of coinsurance. The coinsurance ray forces the decision maker to accept a constant share of the shortfall in state "b", no matter what the change in the level of expected value of income. Again, the existence of coinsurance will provoke a welfare loss on the part of the decision maker. Deductibles are ordinarily used to reduce the administrative burden of the insurance, while coinsurance is a disincentive to moral hazard (cheating). The tradeoffs between the welfare loss occasioned by the deductible or coinsurance and the costs of operating the insurance program would become the basis of a cost/benefit analysis of the design of the optimal policy.

FIGURE II-3

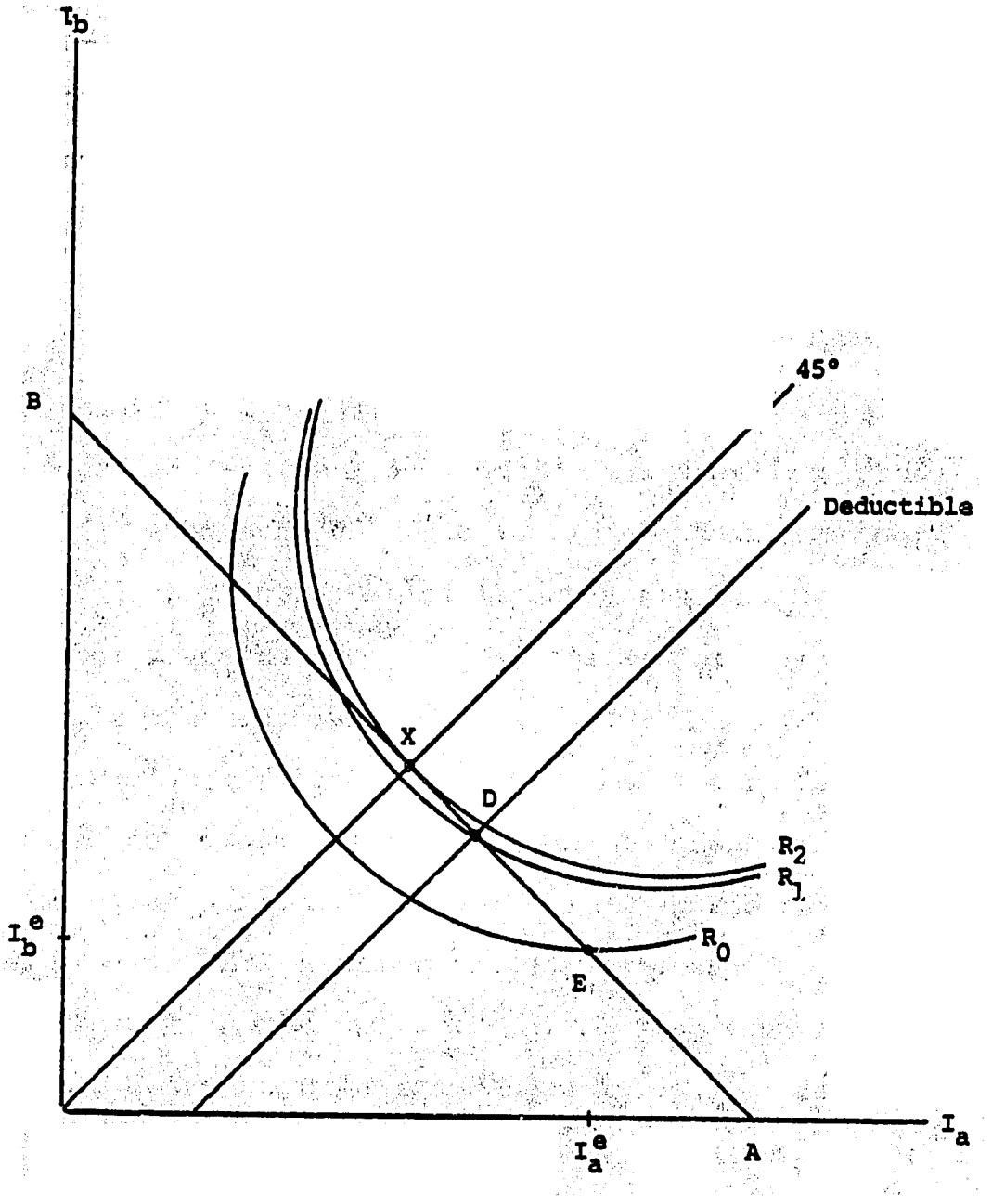
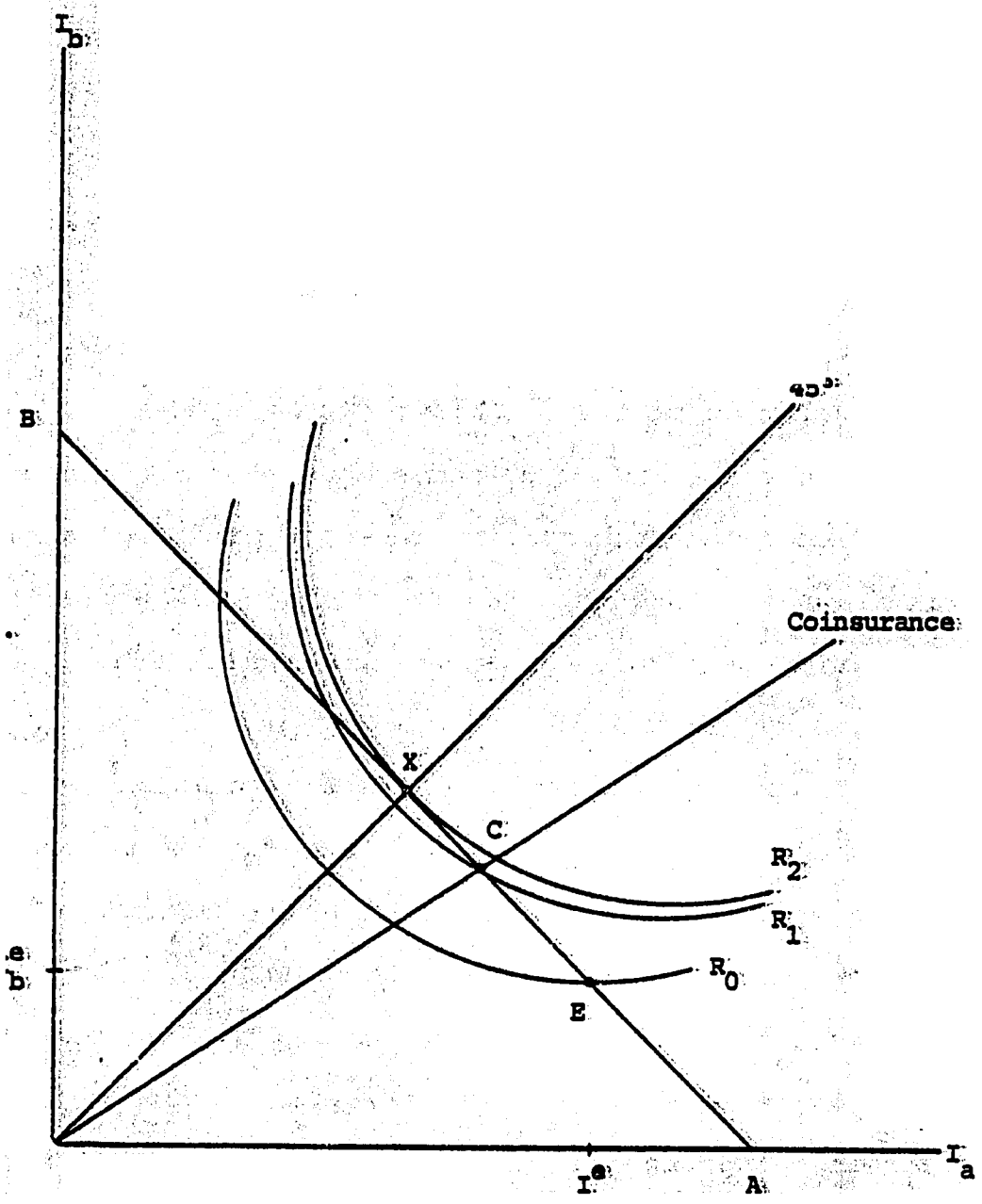


FIGURE II-4



We are now ready to look at the case of crop credit insurance. Keeping in mind that crop credit insurance will be employed in those cases where a publically sponsored credit program is attempting to induce producers to make greater investment by taking on more debt, we introduce in Figure II-5 two production possibility curves PP' and PP". PP' represents the set of incomes resulting from different investment activities which can be undertaken without external equity or debt and employing traditional technology. PP" represents the income outcomes made possible through participation in the publically sponsored credit program. PP" is drawn to represent the interesting case where the public credit makes possible income levels which are higher on average but more variable.

The reader will notice that at point E_2 the slope of PP" changes. From P to E_1 and P to E_2, we assume that the farmer only uses equity to finance production. Since credit can only be obtained to use the modern technology, the use of the traditional technology limits the income level to that obtainable at E_1. If the farmer decides to employ modern technology using only equity, point E_2 can be achieved.

Comparing points E_1 and E_2 in terms of risk preferences, we see that E_1 lies on indifference curve R_0. Point E_2 lies below this indifference curve, implying a lower level of

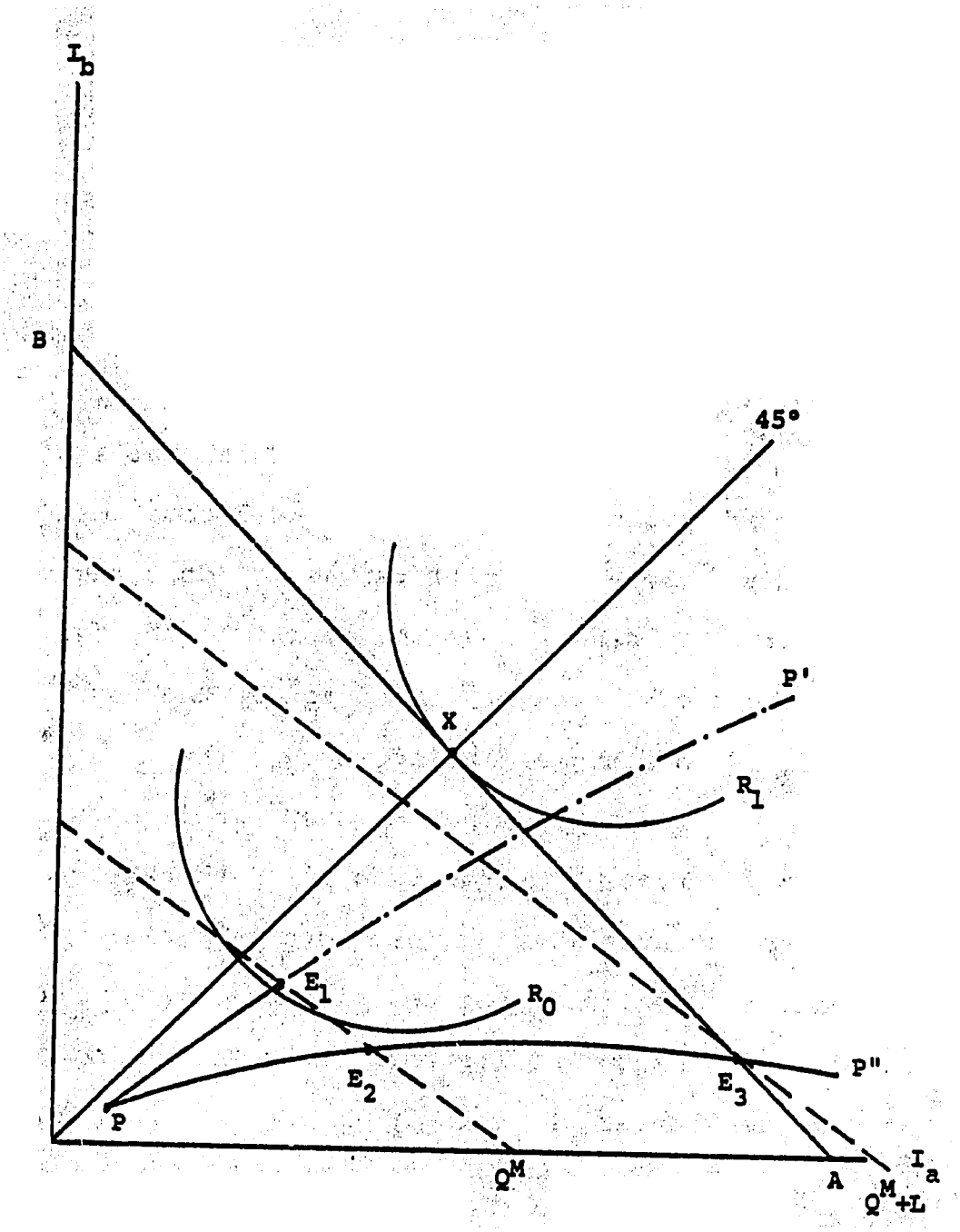
satisfaction in spite of the fact that it has a higher expected income. Thus, the risk averse farmer in this example will choose not to employ modern technology, even though the expected net benefit is positive.

Suppose now that the farmer is offered credit to increase the level of production from point E_2 to E_3. The slope of PP" from E_2 to E_3 declines because the farmer must make interest payments in state "b", even though the level of gross income is not increasing. Thus, while E_3 represents a much higher level of expected income than either E_1 or E_2, the farmer will still refuse to adopt the modern technology. It can even be the case that the farmer will refuse the credit even if forced to use the new technology, i.e., E_2 is on a higher indifference curve than E_3.

Now consider the impact of crop credit insurance. If the farmer borrows L, production will increase to point E_3, where the actuarially fair insurance will allow the farmer to redistribute income between states of nature so as to achieve point X on indifference curve R_1. Clearly the farmer is much better off both in income and risk terms. With the crop credit insurance, the farmer depicted here has a clear incentive to adopt the new technology financed by the loan.

The introduction of a deductible or coinsurance into this model should be obvious. The deductible or coinsurance

FIGURE II-5



would make impossible the achievement of expected income in all states of nature; some point below X on the BA insurance line would be obtainable. Consider the case where PP' was the production possibilities curve for the modern technology (i.e., higher levels of production were not significantly more risky). In such a case, a deductible like that shown in Figure II-3 could make insurance undesirable. The same can be true of coinsurance. Since there is no a priori reason why new technology must be more variable than traditional technology, it is an empirical question how much change in economic behavior will be produced by the introduction of insurance, especially where deductibles and coinsurance are used to control administrative costs. It is important to realize that it is the behavioral change which makes the introduction of an actuarially fair crop credit insurance socially profitable. A risk averse individual will always be happier with a full-coverage insurance, but if no behavioral change is forthcoming (i.e., if the farmer would have adopted the new technology anyway), then crop credit insurance becomes a kind of income transfer program -- taxpayers subsidizing the income stability of small farmers.

Lastly, it should be clear that programs that change farmer assessments of risk can also be effective in inducing the adoption of new technology. Assume that in Figure II-5,

PP" represents the farmer's poorly informed assessment of the production possibilities offered by new technology financed with official credit. If through informational activities (demonstration plots, extension service meeting or training programs), the farmer can be induced to shift PP" upward, it could happen that the new technology will be adopted without insurance. In Chapter 4, we will discuss instances where this kind of reassessment is evident.

The mathematical counterpart of the Figure II-2 is the following:

$$\max L = pU(I_a) + (1-p)U(I_b) + \lambda\{I_b - I_b^e - \pi(I_a^e - I_a)\} \tag{16}$$

where

π is the rate of exchange between states of nature, if $\pi = p/(1-p)$ the insurance is actuarially fair, and

λ is the Lagrange multiplier.

Taking first order conditions, we have:

$$\partial L/\partial I_a = pU_a + \lambda = 0 \text{ , and} \tag{17}$$

$$\partial L/\partial I_b = (1-p)U_b + \lambda\pi = 0 \text{ .} \tag{18}$$

Dividing (17) by (18) produces

$$pU_a/(1-p)U_b = \pi \quad \Rightarrow \quad p/(1-p)\cdot dI_b/dI_a = -\pi \tag{19}$$

which is to say that the slope of the indifference curve is tangent to the insurance line. Furthermore,

$$U_a/U_b = (1-p)/p \cdot \pi = 1 \tag{20}$$

since $\pi = p/(1-p)$. This is to say that an actuarially fair insurance scheme will produce an equal distribution of income across states of nature since $U_a = U_b \Rightarrow I_a = I_b$, given the monotonic nature of the utility function. These derivations coincide with those developed in Ehrlich and Becker (1972).

In order to represent mathematically the case represented in Figure II-5, it is convenient to change (16) slightly. Instead of the Lagrange constraint, we will let:

$$s = I_a^e - I_a \tag{21}$$

which implies that

$$I_b - I_b^e = \pi(I_a^e - I_a) = \pi s . \tag{22}$$

Substituting $I_a^e - s$ for I_a and $I_b^e + \pi s$ for I_b, we have the equivalent of (16):

$$\max L = pU(I_a^e(Q,L) - s) + (1-p)U(I_b^e(Q,L) + \pi s) \tag{23}$$

where

$I_a^e(Q,L)$ and $I_b^e(Q,L)$ are the endowment income levels

in the two states of nature as a function of the

Substitute (3) for $I_a^e(Q,L)$ and $I_b^e(Q,L)$ and we obtain:

$$\max L = pU[r_a(Q+L) - iL - s] + (1-p)U[r_b(Q+L) - iL + \pi s] \tag{24}$$

Taking the partial derivatives with respect to s, the income transfer, we have:

$$\partial L/\partial s = pU_a(-1) + (1-p)U_b\pi = 0, \tag{25}$$

which implies,

$$U_a/U_b = (1-p)/p \cdot \pi = 1, \tag{26}$$

if the insurance is actuarially fair.

Suppose now that the farmer wants to rely on his own resources ($Q > 0$, $L = 0$), then we differentiate (24) with respect to Q:

$$\partial L/\partial Q = pU_a r_a + (1-p)U_b r_b > 0$$

as long as $pU_a r_a > -(1-p)U_b r_b$. This will always be true if $r_a > r_b > 0$, but it can also be true for some $r_b < 0$. Thus, the objective function is unbounded; only equity limits it.

Now consider the impact of introducing debt without insurance ($Q > 0$, $L > 0$, $s = 0$):

$$\partial L/\partial L = pU_a(r_a - i) + (1-p)U_b(r_b - i) \lesseqgtr 0 , \tag{28}$$

as $pU_a(r_a - i) \lesseqgtr -(1-p)U_b(r_b - i)$. Thus, some cases where $r_a > r_b > 0$ may exist in which an increase in the level of debt will lead to a decline in the level of utility, since $U_b > U_a$ for a risk averse individual.

When we introduce insurance with debt, we find:

$$\partial L/\partial L = pU_a(r_a - i - \frac{\partial s}{\partial L}) + (1-p)U_b(r_b - i + \pi\frac{\partial s}{\partial L}) > 0 \tag{29}$$

Since $s = I_a^e - I_a$ and since $I_a = I_b$ where actuarially fair insurance is offered (from (26) $U_a = U_b$ only where $I_a = I_b$), s can be rewritten:

$$s = I_a^e - I_a = r_a(Q+L) - iL - [E(r)(Q+L) - iL]$$

$$= [r_a - E(r)](Q+L) \tag{30}$$

implying $\partial s/\partial L = r_a - E(r)$. Substituting in (29), we have:

$$\partial L/\partial L = pU_a(E(r) - i) + (1-p)U_b[r_b - i + \pi(r_a - E(r))] \tag{31}$$

We make the sensible assumption that the expected rate of return is greater than the interest rate, i.e., $E(r) > i$. Thus, the bracketed term becomes:

$$r_b + \pi(r_a - E(r)) - i = (1-p)r_a + \pi(1-p)r_a - i$$

$$= (1-p)r_b + pr_a - i = E(r) - i > 0 \ , \qquad (32)$$

since $\pi = p/(1-p)$ and $E(r) = pr_a + (1-p)r_b$. Thus, $\partial L/\partial L > 0$, when insurance is offered. This means that as long as the technological package chosen by the credit program has a positive expected net rate of return $(E(r) - i > 0)$, then the risk averse farmer will use as much insured credit as is offered.

If the farmer is risk neutral, U_a and U_b are equal in all of the above equations, and insurance will have no behavioral impact on the debt-financing decision. The only consideration will be the expected rate of return on investment exceed the interest rate:

$$pr_a + (1-p)r_b > 0 \ , \text{ or} \qquad \text{(in 27)}$$

$$p(r_a - i) + (1-p)(r_b - i) > 0 \qquad \text{(in 28)}$$

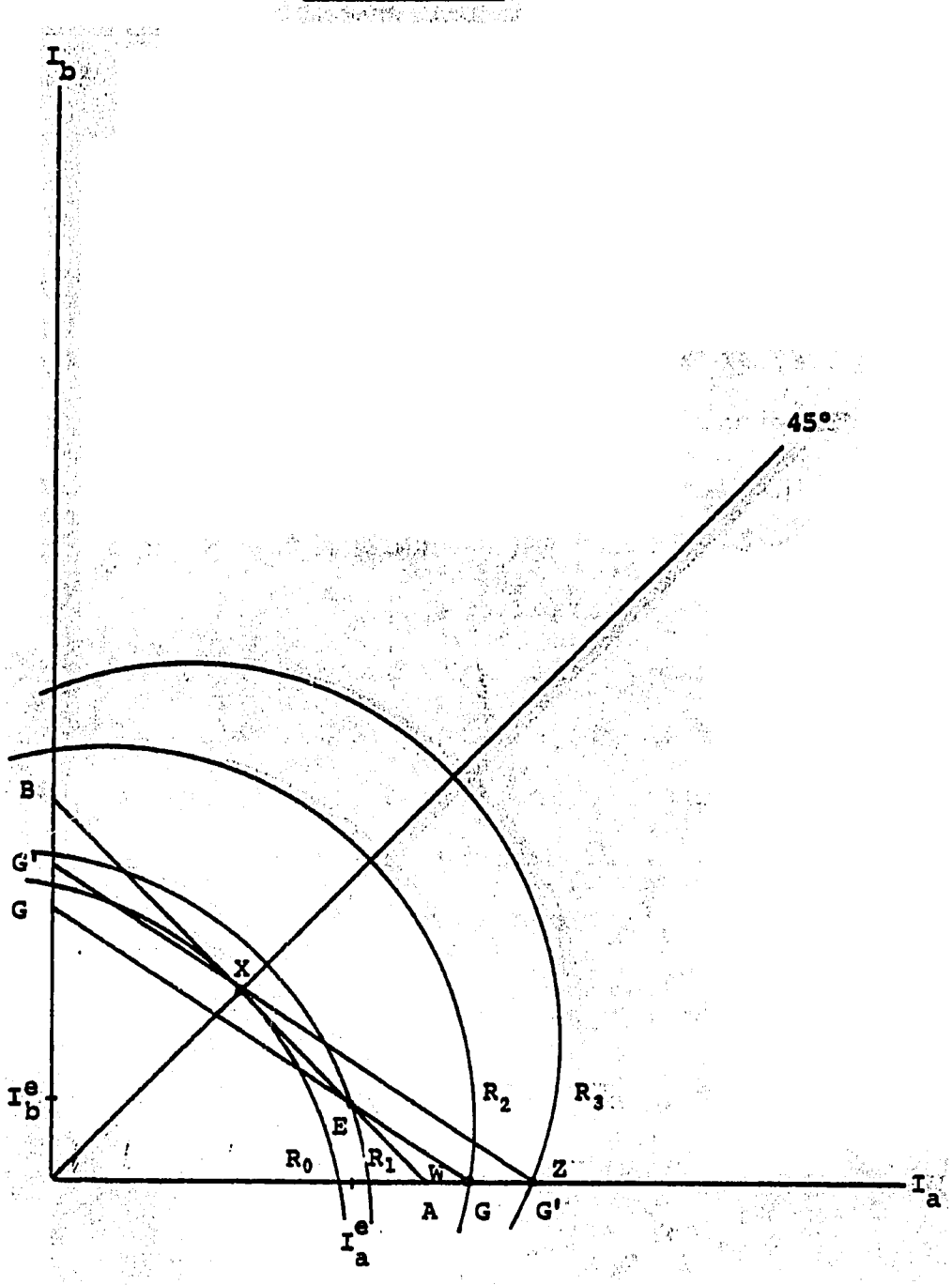
We see, therefore, that, in situations like that represented in Figure II-5, crop credit insurance is likely to have a positive impact on the willingness to borrow. The inclusion of deductibles or coinsurance would only complicate these results slightly, diminishing the effect of insurance on the demand for credit but leaving their general nature unchanged.

Compulsory Insurance and Non-Risk Averse Decision Makers

We will take a short detour here to deal with an issue raised by Roumasset (1976) in his article criticizing crop insurance. Roumasset claims that risk neutral decision makers will act as though they were risk taking when compelled to purchase insurance. This is an important issue since most crop credit insurance programs are compulsory for those requesting publically financed loans. Returning to Figure II-5, we recall that the risk neutral decision maker has a utility function which produces indifference curves parallel to the fair odds line BA. In Figure II-5, the highest linear indifference curve obtainable is BA at point E, the point with the highest expected value of income. The risk neutral decision maker is indifferent between point X and point E, since they both lie on the same indifference curve. Thus being forced to purchase insurance, i.e., being compelled to accept point X instead of E, is a matter of indifference to the risk neutral decision maker. Of course, Roumasset's argument falls on completely logical grounds - a risk neutral decision maker is by definition indifferent to the way in which income is redistributed across states of nature. Therefore, even if the insurance scheme were actuarially unfair, the risk averse decision maker will continue to choose points on the PP" curve if their expected value is greater than those points obtainable on the PP' curve.

Let us now turn to the question of the effect of compulsory insurance on the risk-taking individual. Figure II-6 represents this case graphically. The initial endowment is again point E. If the gambler is forced to accept insurance, i.e., forced to accept point X, utility will decline from that of indifference curve R_1 to indifference curve R_0. Suppose, however, the individual lives in a society which permits gambling. (Mexico and Panama both have national lotteries whose proceeds are used for public welfare programs.) In this case, the risk-taking individual can redistribute the proceeds of investment activities through gambling to make the final income stream as variable as possible. In Figure II-6, the gambling line GG is drawn through the initial endowment point E; the gambler can now redistribute income between states "a" and "b" freely. In this case, point W is selected, reaching indifference curve R_2. However, if the gambler is forced to purchase insurance, the gambling line can then be drawn through point X. The new gambling line G'G' makes it possible to achieve point Z and indifference curve R_3. Point X on the insurance line BA is not reachable through gambling because gambling is not actuarially fair (even government lotteries generate some profit in addition to administrative costs). Thus even the gambler can be better off with compulsory insurance. The only limitation is that some gambling

FIGURE II-6



opportunities exist. In the case where gambling opportunities are absent, the government could start a lottery in rural areas in order to insure that risk-taking farmers incur no welfare loss from compulsory insurance.

Alternatives to Crop Insurance - Diversification and Share Contracts

Another criticism levelled by Roumasset (1976) against crop insurance is that other mechanisms for reducing or avoiding risk are already available to small farmers. We will deal with two such mechanisms here: crop diversification and share contracts.

Crop diversification is practiced for two different reasons. First, crop diversification can help achieve a more efficient resource allocation, and second it can help reduce risk. As an example of resource diversification, consider the following linear programming model:

$$\max \pi = px_1 + px_2 \tag{33}$$

$$\text{s.t.} \quad \begin{aligned} x_1 + x_2 &\leq 1 \text{ acre} \\ 2x_1 + x_2 &\leq 1 \text{ labor} \\ x_1 + 2x_2 &\leq 1 \text{ capital} \end{aligned}$$

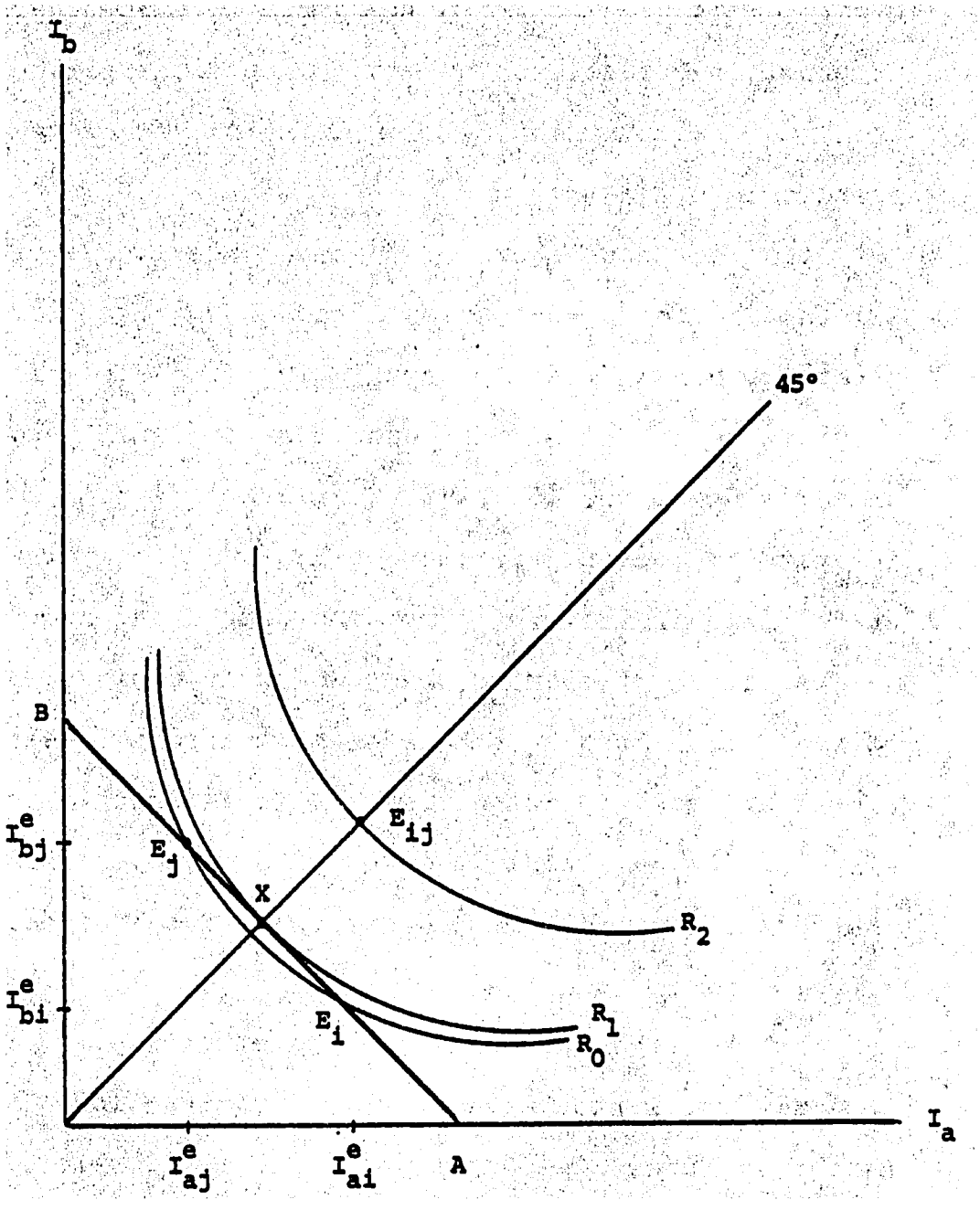
Notice that to grow only x_1 ($x_1^* = \frac{1}{3}$) uses all of the labor but leaves some capital unused; $\pi = \frac{1}{3}p$. If only x_2 is

is grown ($x_2^* = \frac{1}{2}$), then some labor is unused; $\pi = \frac{1}{2}p$. Clearly, both can be grown ($x_1 = x_2 = \frac{1}{3}$), and the level of profit increases to $\pi = \frac{2}{3}p$. Crop diversification, then, can be motivated by considerations other than risk aversion.

Consider now Figure II-7, as an ideal case of crop diversification. Here, crop i and crop j are mirror images of each other (perfectly negatively correlated) in that they lie on the same indifference curve equally spaced on either side of the 45° ray. When crop i performs poorly in state "b", crop j performs well, and vice versa for state "a". If we were to combine crop i and crop j into a diversified production plan, we could achieve point X, moving from E_i and E_j, the endowment income levels for crop i and crop j, respectively. If resource allocation efficiencies were also achieved through diversification, then point E_{ij} might be the outcome, with a higher expected income.

For a given technology and level of inputs, insurance can only redistribute income along the BA line. Thus, a perfectly diversified crop portfolio would remove the need for insurance for a risk averse decision maker. If resource allocation efficiency were achievable, then diversification would be superior to insurance.

FIGURE II-7



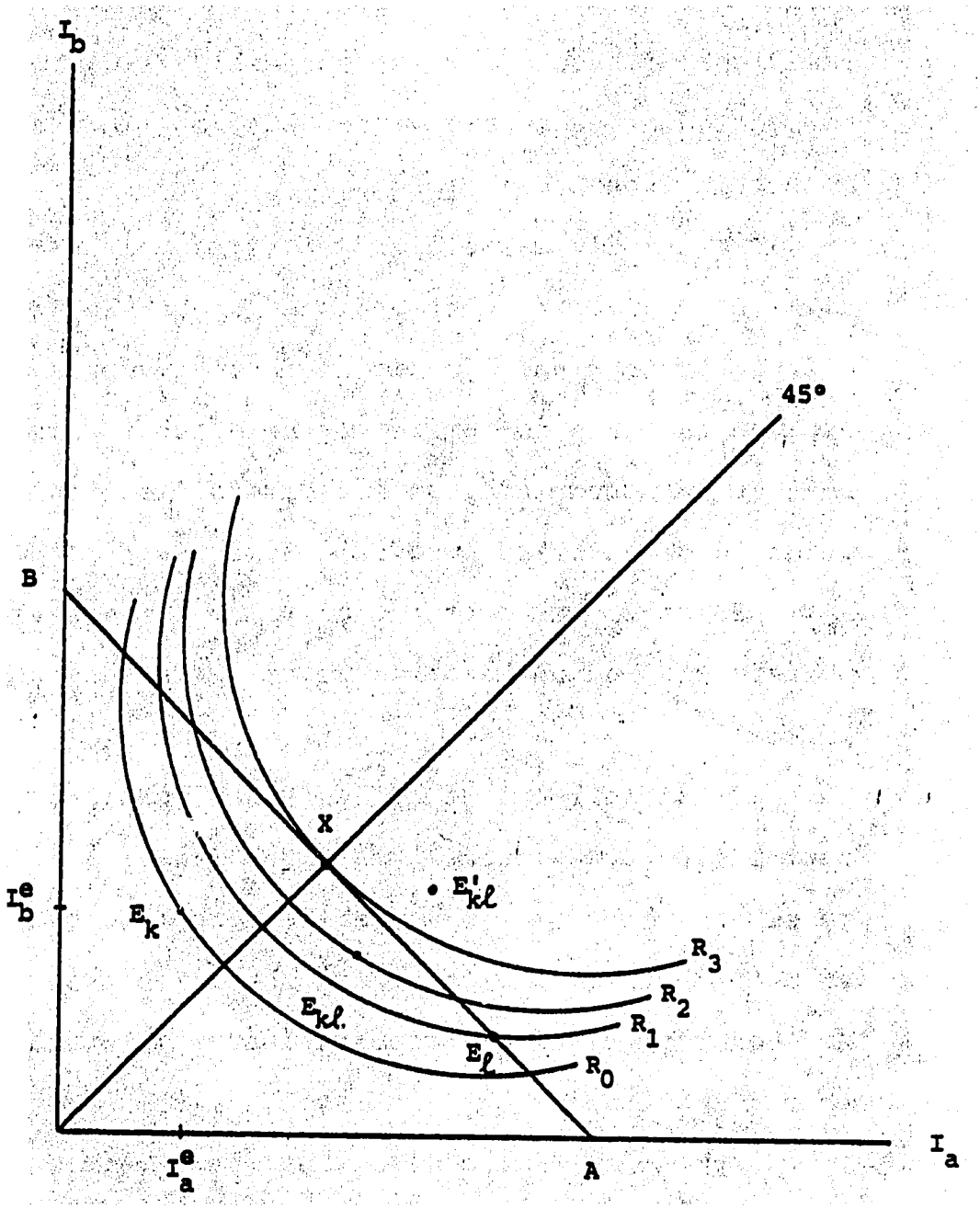
We should point out, however, that resource diversification does not necessarily reduce variability. If crop i and crop j have income streams which are highly positively correlated, then income variability may increase as much or more than expected income

The normal scenario in which crop diversification takes place is like that depicted in Figure II-8. Here the two crops k and ℓ generate income endowments E_k and E_ℓ. Because they are not perfectly negatively correlated and because we assume no resource diversification efficiency gains, a diversified portfolio will yield income endowment $E_{k\ell}$. Point $E_{k\ell}$ is better than point E_ℓ in terms of risk preferences and better than point E_k in terms of expected income.

If the goal of the agricultural credit program is to optimize output (income), then the farmer should be induced to select point E_ℓ. This can be done through insurance, which will allow the farmer to move from point E_ℓ to point X. Under these circumstances, insurance would induce specialization at the farm level.

Suppose in Figure II-8 that the diversification of crop ℓ and k produces an efficiency gain, yielding an income endowment like $E'_{k\ell}$. One might conclude that insurance caused a welfare loss by encouraging specialization, since $E'_{k\ell}$ lies on a higher indifference curve than point X. The

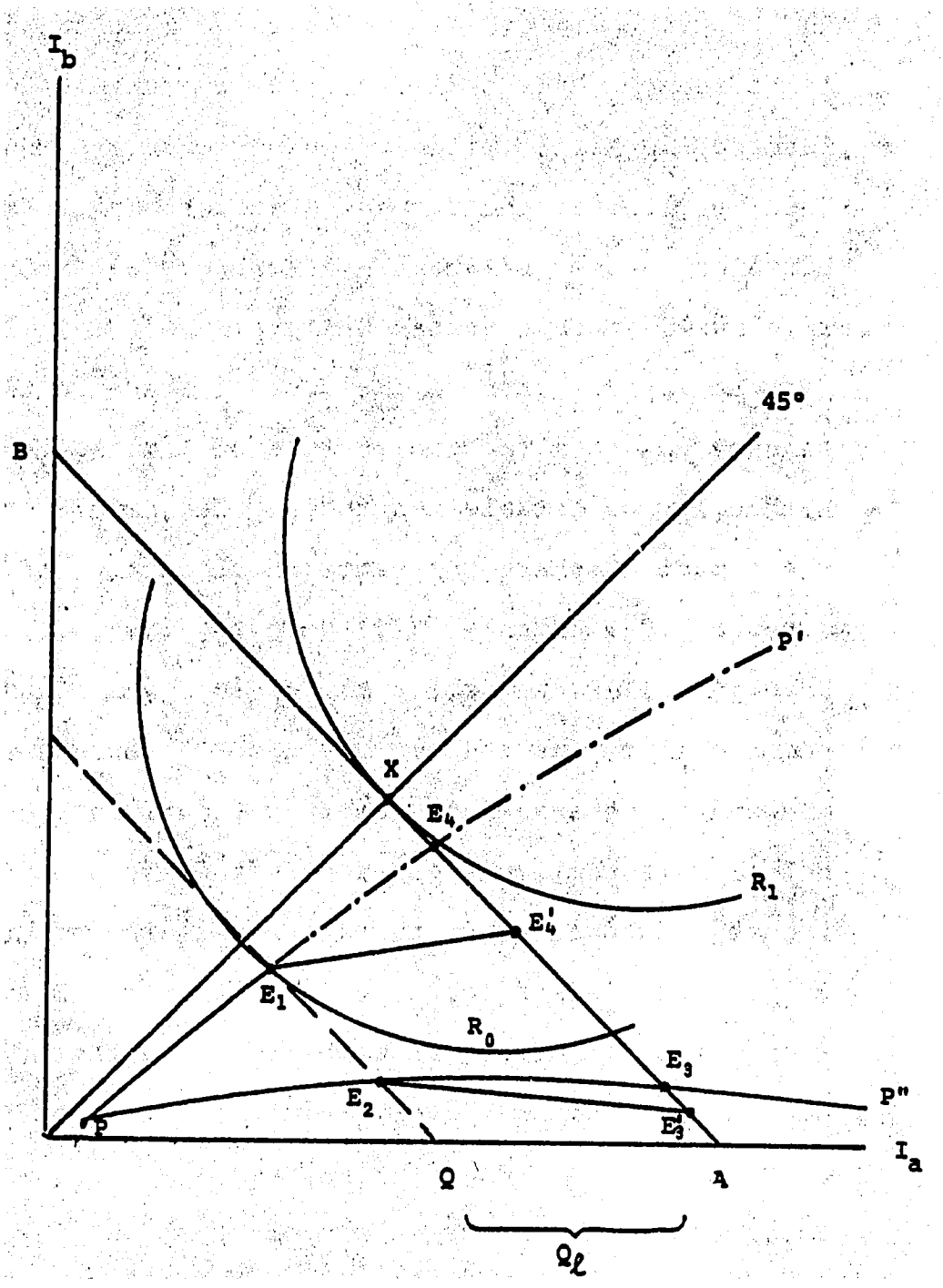
FIGURE II-8



deficiency is not, however, in the insurance, but rather in the technological design of the credit program. There is no reason why the diversified crop plan $k\ell$ cannot be insured; in Mexico mixed cropping loans are insured. Therefore, as long as the crop diversification is imperfect in terms of income variability, there may be an insurance plan which will improve farmer welfare.

Let us now turn to the case of share contracts. Share tenancy has been recognized as a risk management mechanism, although considerable controversy has been generated over the impact of share contracts on allocative efficiency (Cheung, 1969; Huang, 1973; Newbery, 1975, Stiglitz, 1974). In Figure II-9, we depict the case of share tenancy and compare it to insurance. PP' and PP" represent the income endowments generated by the traditional and modern technologies respectively given varying levels of financial inputs. Suppose that the farmer has own resources equal to Q, which is sufficient to achieve point E_1 with traditional technology and E_2 with modern technology. Suppose now that an outside investor is willing to add capital Q_ℓ in return for a share of the income. If the income payed to the external equity is proportional to its contribution to total assets, then the farmer's net income will remain constant, assuming no shift in technology. The new income endowment for the enterprise will be E_4 in the case of the

FIGURE II-9



traditional technology and E_3 in the case of the modern technology. The farmer will receive as a share E_1 and E_2, respectively, and external equity will receive the remaining income. This is the classic result when payment proportional to asset contribution is assumed (Adams and Rask, 1968).

The alternative to share tenancy would be a fixed rent tenancy. This is functionally equivalent to debt, since the rent must be paid irrespective of the state of nature. Thus, the addition of Q_1 (an additional tract of land) under a fixed rent contract will move the farmer from E_1 to E_4' and E_2 to E_3', given the traditional and modern technologies respectively. In some cases, the farmer is better off with a fixed rent contract than a share contract (point E_4' versus E_1). In other instances, the farmer will be better off with the share contract (point E_2 versus point E_3'). All of these points, however, are inferior to point X, which could be achieved through insurance. Recognizing that deductibles or coinsurance might create exceptions, insurance would seem to be a more effective method of risk management than share tenancy.

The principal benefits of share tenancy may arise from a kind of resource diversification. Share tenancy is often a means whereby individuals with too much labor and not enough capital join forces with persons with too much capi-

tal (land) and too little labor. The risk reduction may only be a secondary benefit.

In certain cultural contexts, share tenancy has been an instrument of economic exploitation of one group by another. It is customary to find that most economic relationships between the dominant and subordinate groups are characterized by economic inequities -- where share tenancy is exploitative, so are wage labor and fixed rent contracts. Thus, the exploitation appears to stem from social, political and cultural factors. In such situations, programs to eliminate share tenancy are likely to be ineffective so long as the underlying causes of exploitation persist. Where these kinds of economic inequities do not exist, for example the American Midwest, share tenancy is a highly desirable form of economic contract.

Notwithstanding the above, one could make an argument for crop credit insurance vis-a-vis share tenancy in those areas where socio-cultural factors create a climate of economic inequity. If the agricultural credit program treats farmers with economic justice, then crop credit insurance will contribute to social welfare if it can induce farmers who would otherwise become share tenants to use official credit. By increasing the demand for official credit and by undermining the economic power of the dominant

partner in an inequitable share tenancy, crop credit insurance can help achieve certain social goals in addition to stimulating production.

Lastly, let us consider the case where the risk characteristics of a production technology change. Suppose after reaching point E_1 in Figure II-8, the production possibilities curve PP' veered sharply away from the 45° ray. The effect of this is that the share tenancy production possibilities curve would no longer be coincident with PP', but rather would lie below it. Similarly, if PP' were to quickly converge on the 45° ray, the share tenancy production possibilities curve would lie above PP'. Therefore, a substantial change in the scale of production due to share tenancy which changes the risk characteristics of the income endowments would make share tenancy either very desirable or undesirable, depending on the nature of the shift. A more detailed analysis of this issue is beyond the scope of this thesis.

Again, it seems reasonable that an insurance scheme can be devised which will be preferable to most share contracts. With both diversification and share contracts, it is an empirical question whether a practical insurance scheme can be implemented which will improve small farmer welfare beyond that obtainable through existing risk

management mechanisms at a reasonable social cost. This question will be addressed in detail in Chapter 5. Here we close simply by pointing out that there is no convincing *a priori* argument that crop credit insurance is not worthy of serious (empirical) considerations as a risk management tool.

CHAPTER 3

CROP CREDIT INSURANCE IN A DYNAMIC SETTING

Introduction

This chapter examines crop credit insurance in a dynamic context. We will review some of the literature on temporal risk, and then set forth two basic models to examine crop credit insurance in terms of temporal risk.

With these basic models, we will discuss the two principal alternatives to crop credit insurance which have been proposed -- forced savings and forecasting. We will see that these are not effective risk management mechanisms under the conventional definitions of risk aversion.

We will then consider the question of the impact of crop credit insurance on technical change in a dynamic setting. The results are very similar to those derived in Chapter 2.

Lastly, we will examine the effect which crop credit insurance might have on the supply of credit, and we will look at the impact of loan default on both the credit program and the farmer-borrower.

Background on Temporal Risk

Most important human decision making under uncertainty is embedded in time -- a decision is made in the present,

and the outcome is not known until some future moment. Uncertainty usually involves waiting. To the extent to which this is true, the static models discussed in Chapter 2 ignore some important characteristics of decision making under risk.

Crop credit insurance is clearly a mechanism for dealing with temporal risk. What is insured is the investment of the farmer financed through a publically sponsored credit program. The consequences of the investment decision are not known for several months after the decision is made, and they are felt for the ensuing year in the farm household's consumption patterns.

Let us begin by considering the characteristics of decision problems where both time and risk are involved. One problem, analyzed by Yaari (1965), deals with the uncertainty of the time horizon. This is the classic life-cycle savings problem where risk enters in terms of the uncertainty of the life time duration. Yaari, using a calculus of variations approach, proved what Fisher had intuitively perceived, that the uncertainty of the time horizon would cause the rational consumer to shift consumption to the present. This is fundamentally the same effect which is received when a discount rate is adjusted upward to account for risk; a higher risk adjusted discount rate leads to decisions which emphasize present consumption

over future consumption. In our later discussion, we will not deal with uncertain time horizons, but we will develop a model with a risk (default) adjusted interest rate.

More apropos of our discussion are the models developed by Sandmo (1970) and Dreze and Modigliani (1972). Both of these articles deal with the effect of future income uncertainty on savings behavior. In this, they fall into a broad literature dealing with liquidity preference and the precautionary demand for money (Patinkin, 1965, Chps. 5-6).

The basic notion is that people save to meet future contingencies. Sandmo (1970) makes a useful distinction between two types of temporal risk: income risk and capital risk. In the simple two period case, income risk refers to the case where a person has known income in Period 1 and uncertain income in Period 2. Given the opportunity to transfer some of Period 1 income to Period 2 via a bond market, the problem is to decide on the level of saving which will optimize the person's utility function.

Capital risk differs from income risk in that the individual has an endowment of wealth in Period 1 which can be invested to yield an uncertain income in Period 2. This problem has different properties than the income risk model because of the possibility of loss of the entire wealth in a bad investment. Both of these models will be cast in the states of nature framework used in Chapter 2.

Dreze and Modigliani (1972) decomposed temporal risk into the future prospect and the timeless risk. Again using a two period model, they showed that the risk premium which a risk averse individual will be willing to pay to avoid a temporal risk is composed of the timeless risk premium plus the expected value of perfect information. These results will be discussed in greater detail when we compare the advantages of crop credit insurance and forecasting.

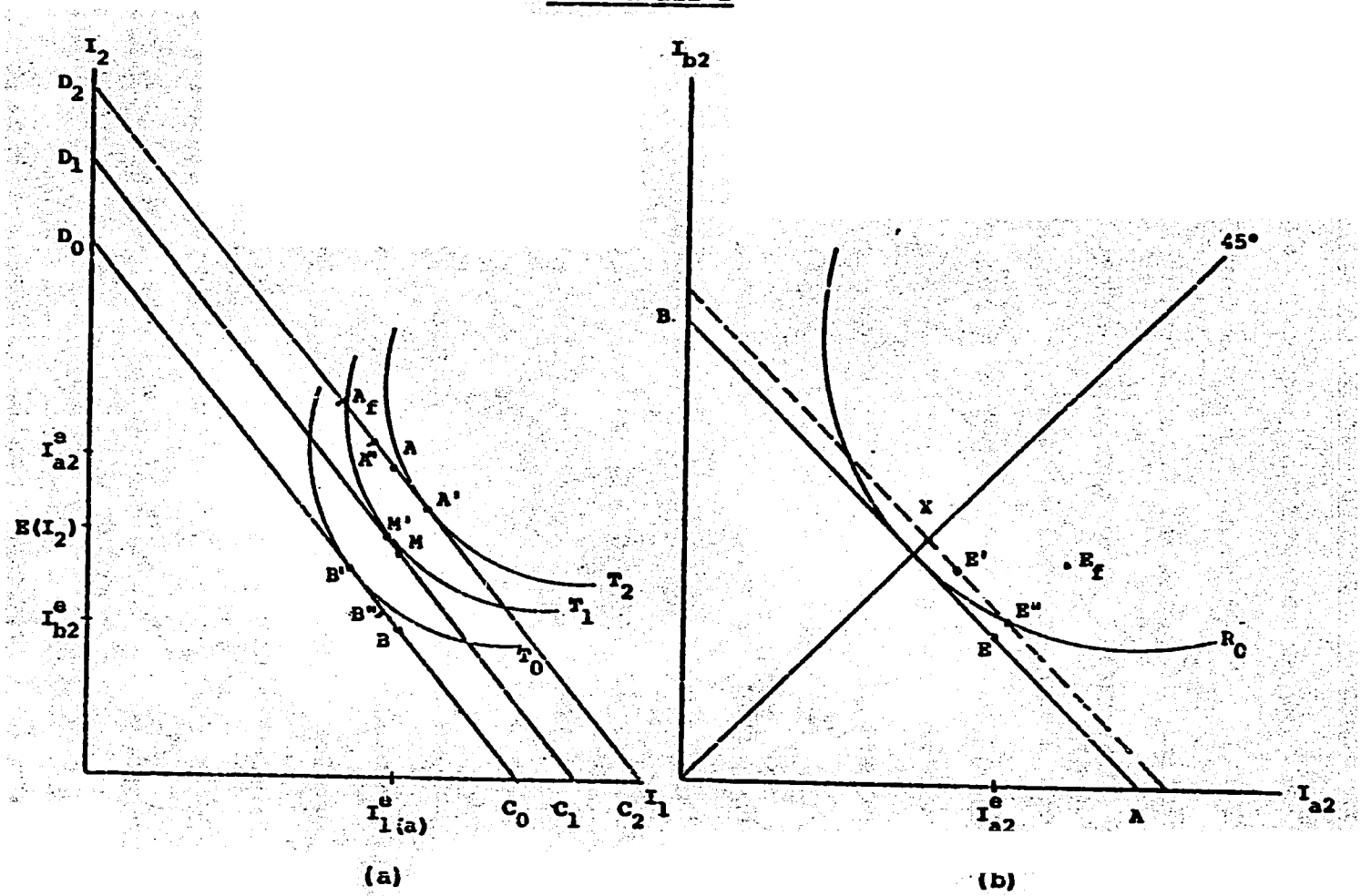
A Simple Intertemporal Model of Income Risk

Consider the following problem. An individual is risk averse and time impatient. The individual has a known income in Period 1, but is uncertain about income in Period 2. If state "a" occurs, income in Period 2 will be I^e_{a2}; if state "b" occurs, then income in Period 2 will be I^e_{b2}. There exists a bond market by which the individual can transfer income between Periods 1 and 2 at interest rate i.

In Figure III-1, we present a graphical representation of this problem. Figure III-1a presents the case where the known income in Period 1 is higher than average. Figure III-2a presents the case where Period 1 income is lower than average.

In Period 2, income can take on two values, I^e_{a2} and I^e_{b2}. Therefore, the two period income endowment is point A

FIGURE III-1


I_2
D_2
D_1
D_0
I^e_{a2}
$E(I_2)$
I^e_{b2}
A_f
A
A'
M'
M
B'
B"
B
T_2
T_1
T_0
$I^e_{1(a)}$
C_0
C_1
C_2
I_1
(a)
I_{b2}
B.
45°
X
E'
E_f
E"
E
R_C
I^e_{a2}
A
I_{a2}
(b)

if state "a" occurs; if state "b" occurs, it is point B. Point M represents the expected endowment, i.e., I^e_{1a} and $E(I_2)$. Since we do not know the future but only the distribution of possible futures, we take point M as our income endowment. Using the bond market line D_1C_1, we can improve our intertemporal utility by moving to point M', where our intertemporal indifference curve T_1 is tangent to the bond market line D_1C_1. The movement from M to M' represents our expected income intertemporal strategy.*

Of course, either state "a" or state "b" must occur. We apply our expected income strategy to the case of state "a" occurring by moving from the endowment point A to point A". This movement parallels that from point M to M', and likewise from point B to point B".

In Figure III-1b, we look at the distribution of income across states of nature. Point E represents the initial endowment before intertemporal redistribution of income. Point E" is the income endowment after the intertemporal distribution of income.

Point E" has a higher expected income than point E. This is due to the fact that the expected income strategy

---

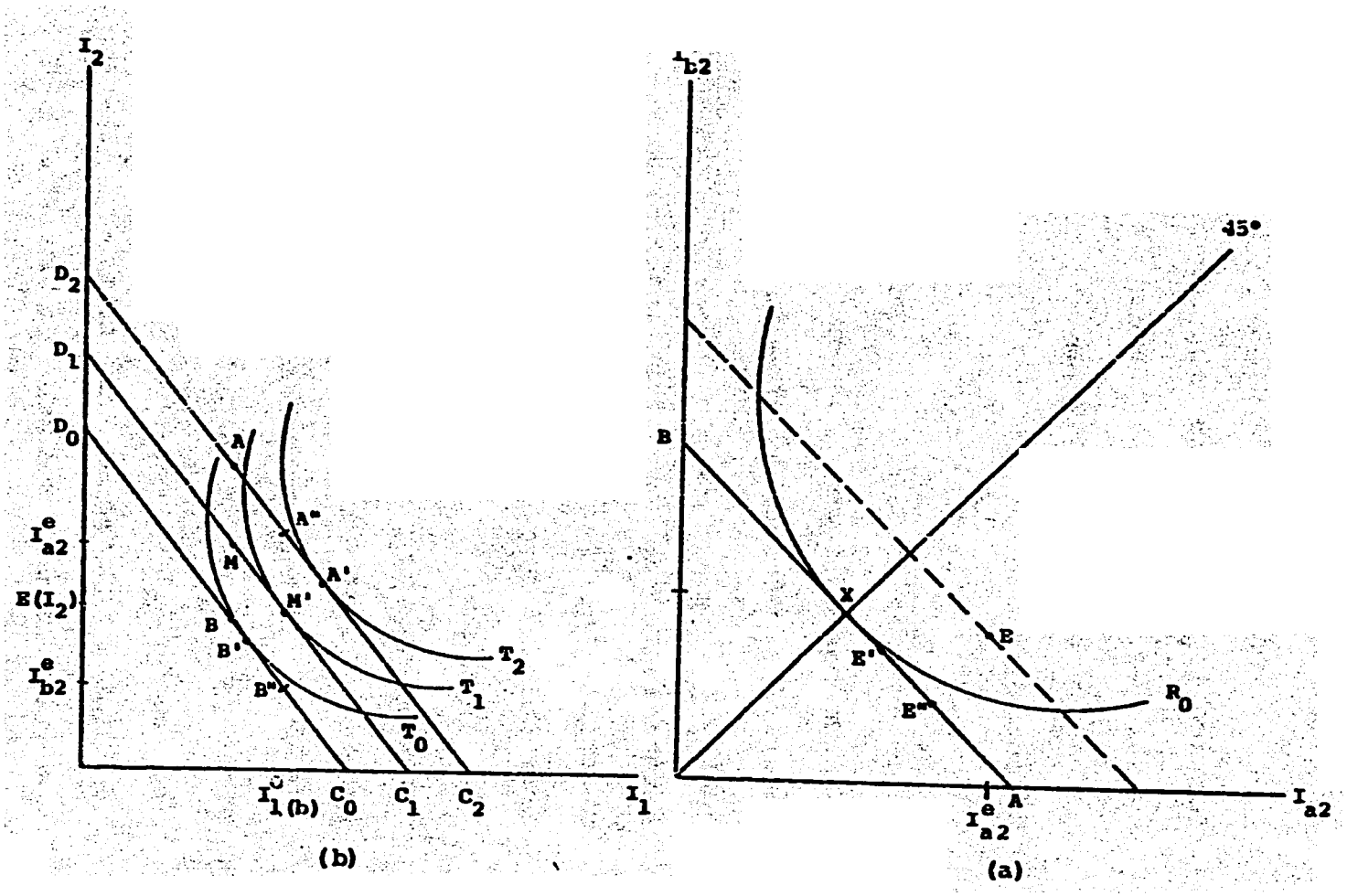
*In the discussion which follows, we will assume perfect capital markets, implying a lack of transactions costs and perfect knowledge of market conditions by borrowers and lenders.

represented by the movement from points M to M' is a savings strategy. Thus, Period 2 is overall better endowed than it would have been without the bond market. The other feature is that the distribution of income across states of nature has not changed. Unless we know the future, we are not able to reduce the variability of future income through savings.

Now we look at the case where the Period 1 income is below average in Figure III-2a. Again, A, B, M represent the two period income endowments for the cases of state "a", state "b" and the expected income. Here, because Period 1 is now poorly endowed and intertemporal preferences are the same, the expected income strategy dictates a redistribution of income from Period 2 to Period 1, i.e., from point M to point M'.

In Figure III-2b, we plot the effect of their borrowing strategy on the distribution of income across states of nature. Point E represents the original income endowment and point E" the income level resulting from the borrowing strategy. Since we must repay in Period 2 the loan which was taken to increase Period 1 income, the expected value of Point E is greater than point E". However, as before, the distribution of income across states of nature has been left unchanged.

FIGURE III-2


I_2
D_2
D_1
D_0
I^e_{a2}
$E(I_2)$
I^e_{b2}
A
A"
A'
M
M'
B
B'
B"
T_2
T_1
T_0
I^e_1(b)
C_0
C_1
C_2
I_1
(b)
I_{b2}
45°
B
X
E
E'
E"
R_0
I^e_{a2}
A
I_{a2}
(a)

From Figures III-1 and III-2, we see that risk averse individuals will always choose an actuarially fair insurance and an equal distribution of income across states of nature irrespective of their time preferences and their intitial asset position.

The Income Risk Model can be stated mathematically as follows:

$$\max L = pU(I_1, I_{a2}) + (1-p)U(I_1, I_{b2}) + \lambda[I_{b2} - \beta I_2 - \pi(\alpha I_2 - I_{a2})] + \gamma[I_2 - I_2^e - (1+i)(I_1^e - I_1)]. \quad (1)$$

where the notation remains the same as that used in Chapter 2 except:

$$\beta = I_{b2}^e / I_2^e, \quad \alpha = I_{a2}^e / I_2^e, \text{ and } I_2^e = pI_{a2}^e + (1-p)I_{b2}^e .$$

Deriving the first order conditions for I_{a2} and I_{b2}, we have:

$$\partial L / \partial I_{a2} = pU_{a2} + \lambda\pi = 0, \quad (2)$$

$$\partial L / \partial I_{b2} = (1-p)U_{b2} + \lambda = 0, \quad (3)$$

implying:

$$U_{a2}/U_{b2} = (1-p)/p \cdot \pi = 1 \quad (4)$$

as we found in the last chapter. In terms of intertemporal

preferences, we derive the first order conditions for I_1 and I_2:

$$\partial L/\partial I_1 = pU_1 + (1-p)U_2 + \gamma(1+i) = U_1 + \gamma(1+i) = 0 \tag{5}$$

and

$$\partial L/\partial I_2 = -\lambda(\beta + \pi\alpha) + \gamma = 0. \tag{6}$$

Remembering that $-\gamma = (1-p)U_{b2}$, $\pi = p/(1-p)$, $\beta = I^e_{b2}/I^e_2$ and $\alpha = I^e_{a2}/I^e_2$, (6) becomes:

$$U_{b2}\,\frac{pI^e_{a2} + (1-p)I^e_{b2}}{I^e_2} = U_{b2} \tag{7}$$

We know from (4) that

$$U_{b2} = U_{a2} = U_2 \tag{8}$$

Hence (6) becomes:

$$U_2 + \gamma = 0\ , \tag{9}$$

and when we divide (5) by (6), we have:

$$U_1/U_2 = \gamma(1+i)/\gamma = (1+i)\ , \tag{10}$$

that is, the indifference curve is tangent to the bond market line, as shown in Figures III-1a and III-2a.

A Simple Intertemporal Model of Capital Risk

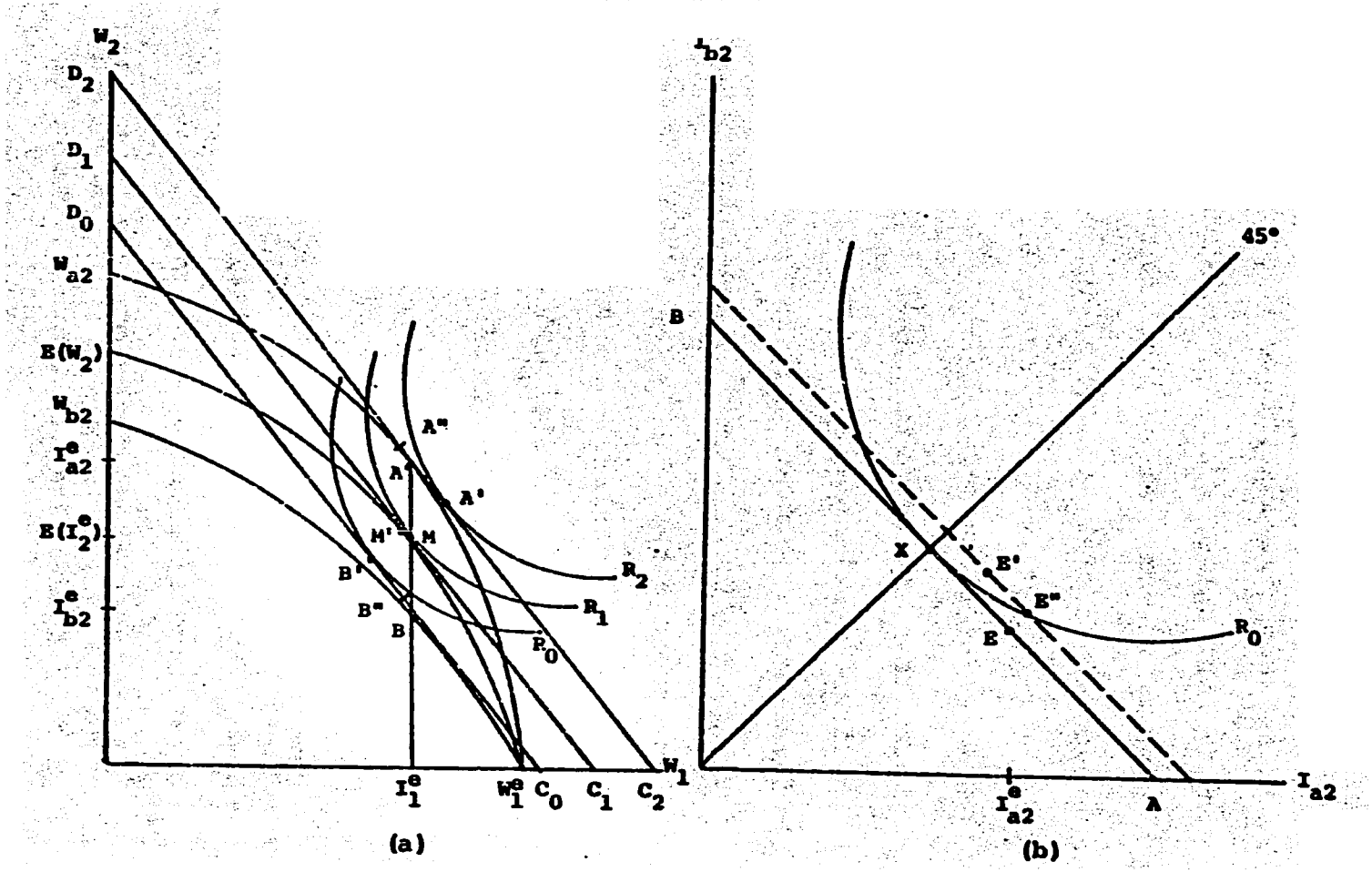
Consider the following problem. An individual is risk averse and time impatient, and possesses an initial wealth in time Period 1 of W_1^e. The individual can consume all or part of the initial wealth. What is not consumed may be invested, thereby producing income in Period 2.

If there exists an efficient bond market which allows the individual to borrow or lend money at the same interest rate, then the decision maker in this context has two choices to make. First, what is the optimal level of investment? Second, what is the optimal level of consumption? In Figure III-3, we see that these decisions are interdependent.

In Figure III-3, we have indicated on the horizontal axis the initial wealth endowment W_1^e. From this point emerge three production transformation curves leading to W_{a2}, W_{b2} and $E(W_2)$. $W^e{}_1W_{a2}$ represents the outcomes of various levels of investment when state "a" occurs in Period 2. $W_1^eW_{b2}$ depicts the consequences on investment when state "b" occurs. Lastly, $W_1^eE(W_2)$ shows what happens on average at each level of investment.

Because these decisions are being made in the context of an efficient capital market, the optimal level of investment is determined at the point of tangency between the financial market lines D_jC_j, $j = 0,1,2$, and the produc-

FIGURE III-3


W_2
D_2
D_1
D_0
W_{a2}
$E(W_2)$
W_{b2}
I^e_{a2}
$E(I^e_2)$
I^e_{b2}
A"
A
A'
M'
M
B'
B"
B
R_2
R_1
R_0
I^e_1
W^e_1
C_0
C_1
C_2
W_1
(a)
I_{b2}
45°
B
X
E'
E"
E
R_0
I^e_{a2}
A
I_{a2}
(b)

tion transformation curves. Since we do not know the future, we will use the $E(W_2)W_1^e$ transformation curve as our forecast. Thus, we select point M as the optimal investment level, giving us a Period 1 investment of $W_1^e - I_1^e$ and a Period 2 expected income of $E(I_2)$.

We have answered only our first question, however; we have, in effect, determined the income endowments of the income risk model. Given these income endowments, we can still rearrange consumption to meet our time and risk preferences. Starting from point M, we determine the expected income strategy by finding the point on the bond market curve where our highest indifference curve is tangent. In this example, this is point M'. The effect of this strategy is to save, i.e., increase the income in Period 2 at the expense of consumption in Period 1. Thus, when state "a" occurs, our income levels are those corresponding to point A"; when state "b" occurs, point B".

When we plot the distribution of these income levels in Figure III-3b, we find that the income endowment level produced by the investment activity, point E, is lower than point E", which incorporates the Period 2 income levels of points A" and B". Again, we see that the distribution of income has not been affected by either investment or bond market activities. Risk preferences will still

dictate the use of insurance to smooth out the income stream.

Mathematically, this problem can be analyzed with the following model:

$$\max L = pU(I_1, I_{a2}) + (1-p)U(I_1, I_{b2})$$

$$+ \gamma[I_2 - P(W_1^e - I_1^e) - (1+i)(I_1^e - I_1)]$$

$$+ \lambda[I_{b2} - \beta I_2 - \pi(\alpha I_2 - I_{a2})] \tag{11}$$

where the notation is the same as that used in (1) except:

W_1^e is the initial level of wealth and

$P(\cdot)$ is the production transformation fucntion of investment.

The first order conditions for (11) are:

$$\partial L/\partial I_1 = pU_1 + (1-p)U_1 + \gamma(1+i) = U_1 + \gamma(1+i) = 0 \tag{12}$$

$$\partial L/\partial I_{a2} = pU_{a2} + \lambda\pi = 0 . \tag{13}$$

$$\partial L/\partial I_{b2} = (1-p)U_{b2} + \lambda = 0 . \tag{14}$$

$$\partial L/\partial I_1^e = \gamma[P' - (1+i)] = 0 . \tag{15}$$

$$\partial L/\partial I_2 = \gamma - \lambda(\beta + \pi\alpha) = 0 . \tag{16}$$

These results are the same as those of the income risk model, except that (15) implies:

$$P' = (1 + i) \ , \tag{17}$$

that is, the marginal value of investment is equal to one plus the interest rate, which is the condition which produces point M in Figure III-3a. The other conditions imply that:

$$U_{a2}/U_{b2} = (1-p)/p \cdot \pi = 1, \text{ and} \tag{18}$$

$$U_1/U_2 = (1 + i) \tag{19}$$

These conditions are the same as those derived in the income risk model.

Since the capital risk model produces the same kinds of results as the income risk model in terms of the effect of the bond market on the distribution of income across states of nature, the succeeding analysis will concentrate on the income risk model. This will make the graphical analysis significantly less messy.

Alternatives to Crop Insurance - Forced Savings and Forecasting

The Government of Australia has instituted an experimental program of forced savings (P.B.R. Hazell, personal communication) for farmers in certain regions of the country

In favorable years, farmers are forced to contribute to a fund which can then be drawn on in case of natural disasters, particularly drought.

An example of a situation like this can be found in Figure III-1a. In Period 1, we enjoy I^e_{1a}, a better than average income. If we knew that state "b" were going to occur in Period 2, we would choose point B'. Suppose the government forced us to save the difference between points B and B'. This would have the effect of changing the intertemporal income levels in state "a" from points A to A_f. When we plot this new information in the state of nature space in Figure III-1b, it produces point E_f. Because we are saving more, E_f is higher than E", but its risk characteristics are unchanged.

Therefore, forced saving will not improve the utility of the farmer in terms of the kinds of risk preferences we have been employing up to now. Such a program could be very beneficial in terms of intertemporal utility improvement, if an efficient bond market did not exist to enable farmers to smooth out their income over time. Such a program would not replace a crop credit insurance program since it does not address the same needs.

There are two circumstances under which a forced saving program might replace a crop insurance program. First, if crop insurance were technically infeasible, forced

savings would represent the only means of transfer income across states of nature. Insurance would be technically infeasible where there was no possibility of diversification of the insurance portfolio. As an extreme case, suppose that all of the individuals purchasing policies faced the same risks. Therefore, if state "b" occurred, all would incur a loss and demand compensation. The insurance program would go bankrupt, unless it collected premiums equal to the compensation payment, in which case no transfer of income across states of nature would take place.

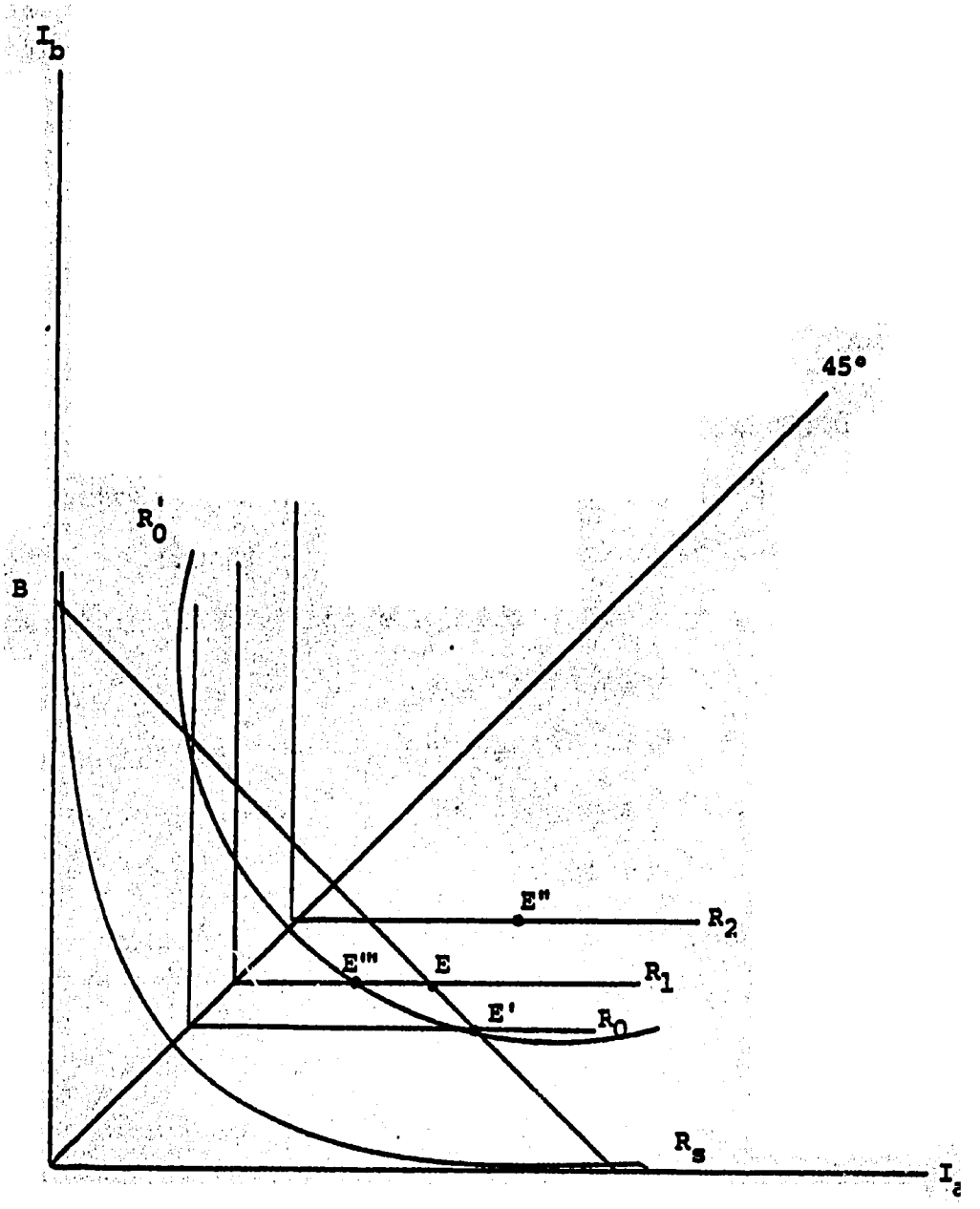
In such a situation, only intertemporal transfers of income can smooth out the income stream for a large group of farmers facing virtually identical risk situations. As a practical matter, almost all insurance programs must face the problem of imperfectly diversified portfolios. Safety reserves are the solution to this problem, and the safety loading in the insurance premium is, in fact, a form of forced savings, transferring income from poorly endowed time periods to favorably endowed ones. In conclusion, a program of forced savings associated with an agricultural credit program is a special case of crop credit insurance where the timeless risk premium rate is set at zero and the safety loading is equal to one plus the interest rate.

Returning to Figure III-1b, we can analyze the effect of an imperfectly diversified insurance scheme on the intertemporal income distribution of the farmer. The insurance scheme would collect from the individual a premium which will shift the income endowment from point E to point X. This shift will include a redistribution of income across time from E to E", and across states of nature from E" to X. In a perfectly efficient financial market, it is immaterial whether the insurance agency or the insured actually does the saving, since they both have access to the same bond market. In practice, opportunities for savings in rural underdeveloped areas are often deficient, and a large insurance program could have access to national or international bond markets which would offer higher rates of return on savings than are available to a small farmer. Thus, a case can be made for and against safety loadings in public insurance programs, depending on the characteristics of local financial markets.

A second case which can be made for the superiority of forced savings over crop insurance depends on a redefinition of the concept of risk aversion. One approach is to define risk aversion in terms of some subsistence floor below which one does not want to fall.

Consider the case represented in Figure III-4. Here we have a series of subsistence preference functions, i.e.,

FIGURE IV-4



$I_b > I_b^s$ and $I_a > I_a^s$. The indifference curve R_1 represents such a preference function. Here the subsistence floor oriented person is indifferent between point E and E''', and prefers point E to point E'. Notice that point E''' has a lower expected value (lies below the fair odds line BA) than point E and lies on the same standard (diminishing marginal utility of income) indifference curve as E'.

Forced savings will produce a change in the income endowment in Figure III-4 corresponding to the change from point E to point E". This may seem reasonable, but other features of this risk model seem unrealistic. For example, the absolute value of the slope of BA could decline drastically, representing an actuarially very unfair insurance scheme, but using indifference curves like R_1, insurance would still be purchased. This does not seem to correspond well with experience

A better model for analyzing the subsistence level question was offered by Leland (1968). Leland developed the concept of decreasing risk aversion to concentration (DRAC). Stated simply, DRAC implies that as the level of income increases, one's aversion to risk decreases. In terms of the graphical model, DRAC would have the indifference curves gradually flatten out as the expected income increased, converging on the risk neutral indifference curve (straight line). Conversely, as income declines, the

indifference curves become increasingly convex. A very convex indifference curve, such as R_s in Figure III-4, would represent a preference set where one was willing to sacrifice a significant amount of income in state "a" to obtain a small amount of income in state "b".

We have not attempted to incorporate this feature into the graphical model for the sake of simplicity, but it is implicitly incorporated into the mathematical model. Let us rewrite the second constraint of (1) as follows:

$$\gamma[FV(I) - FV(I^e)] \tag{20}$$

where

$$FV(I) = (1+i)I_1 + I_2 \quad \text{and}$$

$$FV(I^e) = (1+i)I_1^e + I_2^e$$

Now we can define the marginal value of the income transfer across time as:

$$\partial L/\partial FV(I) = \gamma. \tag{21}$$

From (6) and (9), we know:

$$\gamma = -\lambda[\beta + \pi\alpha] = U_2 \tag{22}$$

If the individual's utility function is characterized by diminishing marginal utility of income, then U_2 will become very large as the expected value of income in Period 2

approaches zero. Only a very perverse intertemporal utility function (a person who expected to die before Period 2) could offset the high marginal value of Period 2 income. Leland should be consulted for a complete discussion of the mathematical properties of utility functions which produce the DRAC effect; the mean-variance model is not among them.

A second alternative to crop insurance is forecasting. Since we have up to this point considered insurance schemes which are costless to the consumer (actuarially fair), let us consider the benefits of a perfect forecasting scheme which is also costless to the consumer.

Returning to Figure III-1a, we can measure the benefits of foreknowledge of what will occur in Period 2. If we knew that state "b" were to occur in Period 2 (i.e., that the two-period endowment would be point B), we would save income in Period 1 so as to achieve point B'; at this point, indifference curve T_0 is tangent to the bond market line D_0C_0.

On the other hand, were we to know that state "a" was going to occur, then we would borrow funds to increase present consumption, achieving point A'. We can now plot the distribution of income across states of nature given perfect forecasting on Figure III-1b. The point E' corresponds to the new distribution of Period 2 income.

We notice that E' and E" (representing the distribution of income under the expected income strategy) both have the same expected income. On average, then, perfect forecasting will lead to the same net transfer of income across time. E' and E" are quite different, however, in terms of the variability of income. Clearly, perfect forecasting allows one to reduce the variability of income. It does not eliminate it.

Forecasting is not a stabilization mechanism, although it has the effect of reducing risk in the presence of other transfer mechanisms. Consider the case of a clairvoyant Robinson Crusoe. Robinson can predict with complete accuracy when state "a" or state "b" will occur; however, he has no mechanism to transfer income over time, being a society of one without a bond market. Thus, in Figure III-1, Robinson's clairvoyance provides no benefits. He cannot move from point E.

Returning to the institutional framework where intertemporal income transfers are possible, we see that the movement from point E to point E' has two components. First, we move from E to E" as a result of saving (income distribution across time). Next, we move from point E" to E', as a result of perfect forecasting. The change in utility from the first step is the value of the intertemporal transfer. The second step represents the expected value of perfect information.

We can see here that a perfect forecasting scheme would not be preferable to a perfect insurance scheme. Wi both insurance and forecasting, a bond market is required to achieve intertemporal optimality. Insurance which is actuarially fair over time can produce a perfectly smooth income stream, whereas forecasting cannot. Insurance, in effect, eliminates the need for information on the future.

We see here a conceptual difference with the argument developed by Dreze and Modigliani (1972). The movement for point E to point X in Figure III-1b does not consist of the present value of future income plus the expected value of perfect information; the second component is the value (utility loss) of income variability.

In the next chapter, we will discuss some of the practical problems of designing and operating an effective crop credit insurance program. They are many and complicated, but they are not nearly as intractable as that of generating a perfect forecast. It seems likely that an economic system which can generate a good forecast of the factors that determine income can implement an even more effective insurance program.

In conclusion, we see that neither forecasting nor forced savings are reasonable substitutes for crop insurance. While forecasting is capable of reducing income variability, forced savings cannot really improve income

distribution across states of nature for the risk averse individual. Forced saving could be effective where crop insurance is not feasible and the bond market is inefficient or incomplete. If the government is to intervene in such a situation, an insurance program with a safety reserve to effect intertemporal income redistribution would appear to offer the greatest benefits.

Crop Credit Insurance and Technical Change in a Dynamic Setting

We will now turn to the question of how crop credit insurance affects technical change in agriculture. In Figure III-5, we present such a problem.

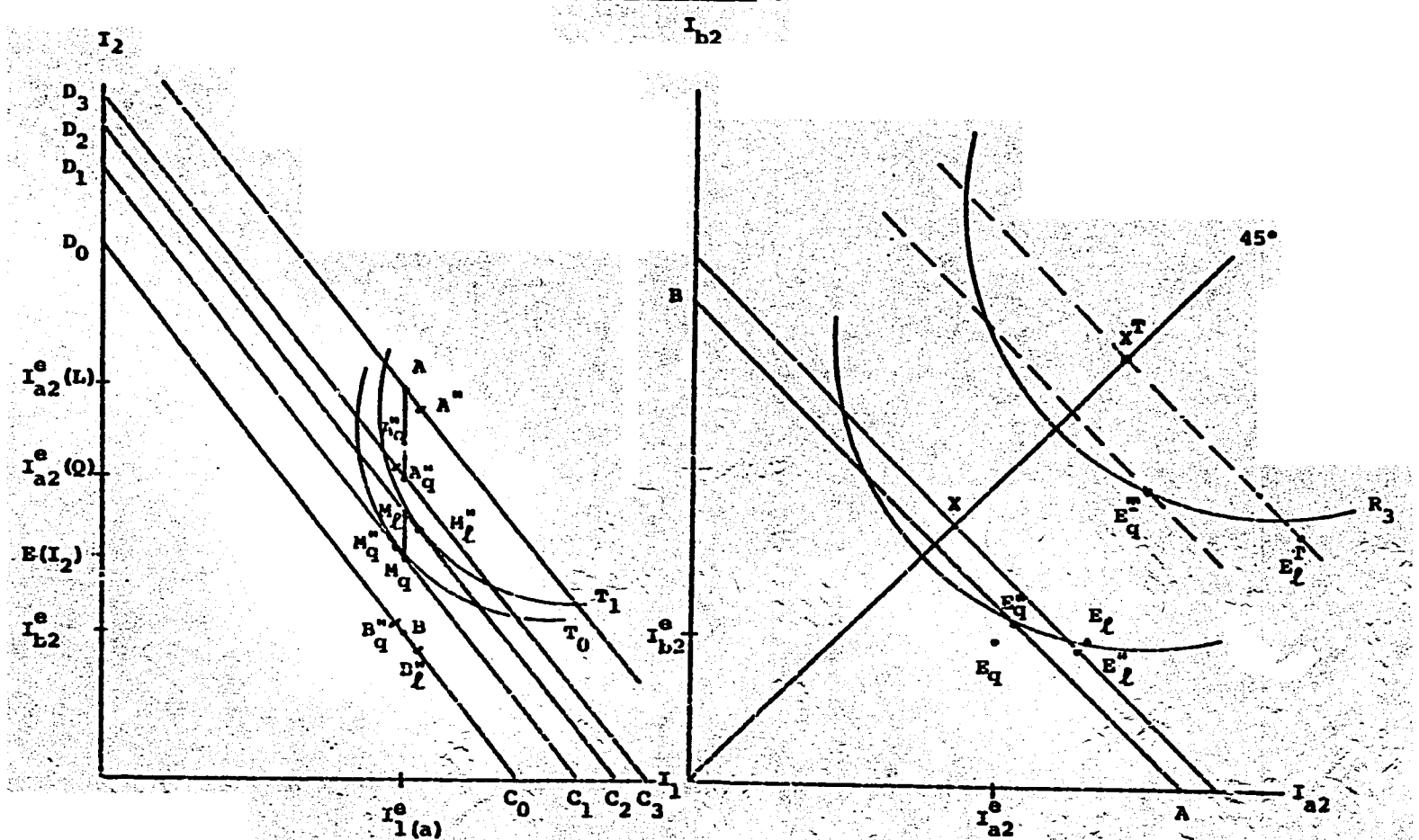
In Figure III-5a, we present the case where a farmer with an initial income endowment of I^e_{1a} in Period 1 can choose to self-finance Period 2 production or to supplement own resources with official credit. For purposes of this model, we will assume that the new technology financed with official credit increases net farm income in state "a" but leaves income in state "b" unchanged. Thus, the income endowment in state "a" can vary from point A_q (self-financed) to A_ℓ (maximum credit). Second period income when state "b" occurs stays fixed at point B. Average income will, however, rise -- in this case, one-half the increase in state "a' income -- from point M_q (self-financed) to M_ℓ (maximum debt).

In Figure III-5b, we present the effect of technical change on the variability of the income stream. Point E_q represents the original second period income endowment with no official credit. Point E_1 shows the distribution of income when maximum credit is used. E_q represents a lower expected income but also a less variable income. Even so, E_q lies below the indifference curve R_0 which includes the point E_1. Thus, the static argument developed in Chapter 2 would lead us in this example to conclude that higher levels of debt will be accepted in spite of the risk magnification effect, because the increase in expected income is sufficient to offset the increase in variability.

This conclusion is drawn, however, without taking into account intertemporal utility considerations. If the farmer self-finances production, the average income corresponds to point M_q. The expected income strategy will lead us to save some Period 1 income, thereby moving to point M_q''. This expected income strategy generates points A_q'' and B_q'' in Figure III-5a and to an income distribution corresponding to point E_q'' in Figure III-5b.

If the farmer decides to take on maximum debt, then the expected income strategy leads to a slight amount of borrowing in Period 1, corresponding to a move from point M_1 to point M_1''. This strategy generates points A_1'' and

FIGURE III-5


I_2
D_3
D_2
D_1
D_0
$I^e_{a2}(L)$
$I^e_{a2}(Q)$
$E(I_2)$
I^e_{b2}
A
A''
A''_q
M''_ℓ
M''_q
M_q
M''_ℓ
B''_q
B
D''_ℓ
T_1
T_0
$I^e_{1(a)}$
C_0
C_1
C_2
C_3
I_1
I_{b2}
B
45°
X^T
X
R_3
E''_q
E^T_ℓ
E''_q
E_ℓ
E_q
E''_ℓ
I^e_{b2}
I^e_{a2}
A
I_{a2}

B_1'' in Figure III-5a and an income distribution represented by point E_1'' in Figure III-5b.

The incorporation of intertemporal utility considerations will lead us to change our decision on assuming debt. Point E_q'' now lies on a higher utility curve than E_1''. However, Period 1 income is higher when debt-financing is used, and we need to include the fact that Period 1 consumption is also changed. When we add the adjusted first period income to second period income, we have the present value of total income. Point E_q^t is the present value of total income when self-financing is practiced. Point E_1^t corresponds to the present value of debt financed income. Debt-financing again produces a higher expected income, but self-financing is preferred due to risk considerations.

When we introduce insurance, we make it possible to achieve point X (or point X^t for the present value of total income). Clearly, point X represents an improvement over self-financed income, point E_q''. Thus, we see that insurance is useful in this dynamic setting in inducing technical change in agricultural production.

A mathematical model of the problem just considered in Figure III-5 is the following:

$$\max L = pU[I_1, I_{a2}] + (1-p)U[I_1, I_{b2})$$

$$+ \lambda[I_{b2} - \beta I_2 - \pi(\alpha I_2 - I_{a2})]$$

$$+ \gamma[I_2 - I_2^e(Q,L) - (1+i)(I_1^e - I_1)] \quad (23)$$

We can eliminate the constraints in (23) by letting

$$m = I_2 - I_2^e \text{ , and} \quad (24)$$

$$s = I_{a2}^e - I_{a2} = \alpha I_2 - I_{a2} \text{ .} \quad (25)$$

Substituting (24) and (25) into (23), we have:

$$\max L = pU[I_1^e + (1+i)m, \alpha(A)I_2^e(A) - s - m]$$

$$+ (1-p)U[I_1^e + (1+i)m, \beta(A)I_2^e(A) + \pi s - m] \quad (26)$$

where the notation is the same as before except:

$A = Q + L$, i.e., total assets;

$\alpha(A) = I_{a2}^e(A)/I_2^e(A)$, the ratio of state "a" income to average income for every level of investment;

$\beta(A) = I_{b2}^e(A)/I_2^e(A)$, the ratio of state "b" income to average income for every level of investment; and

i = the interest rate.

Remembering that $I_{a2}^e = r_s(Q+L) - iL$ for $s = a,b$, then the first order conditions of (26) when $A = Q$ (self-financing, no insurance) are:

$$\partial L/\partial Q = pU_a[(1+i)\partial m/\partial Q + \partial\alpha/\partial Q\ I_2^e(Q) + \alpha(Q)\partial I_2^e/\partial Q - \partial m/\partial Q]$$

$$+ (1-p)U_b[(1+i)\partial m/\partial Q + \partial\beta/\partial Q\ I_2^e + \beta(Q)\partial I_2^e/\partial Q - \partial m/\partial Q]$$

$$= pU_a[i\partial m/\partial Q[(E(r) - i)] + \alpha(Q)(E(r) - i)]$$

$$+ (1-p)U_b\ [i\partial m/\partial Q + \beta(Q)(E(r) - i)] > 0 \qquad (27)$$

since $\partial m/\partial Q = \frac{i+1}{2+i} E(r)$ and assuming $E(r) > i$.

It seems reasonable to assume that the technology being employed have a higher rate of return than the opportunity cost of capital i. Thus, where self-financing is practiced, the only limitation on the level of investment is the avaiability of capital. Since our focus is on small farmers, we can legitimately assume that Q, own resources, are rather limited.

Consider now the case where credit is available ($A = Q + L$) and the farmer is able to use insurance. The first order conditions become:

$$\partial L/\partial A = pU_a[\frac{i(1+i)}{2+i}(E(r)-i) + \partial\alpha/\partial A\ I_2^e(A) + \alpha(A)\partial I_2^e/\partial A - \partial s/\partial A - \partial m/\partial A]$$

$$+ (1-p)U_b[\frac{i(1+i)}{2+i}(E(r)-i) + \partial\beta/\partial A\ I_2^e(A) + \beta(A)\partial I_2^e/\partial A + \pi\partial s/\partial A - \partial m/\partial A]$$

$$(28)$$

where $\partial m/\partial A = \frac{i(1+i)}{2+i}\ (E(r) - i)$.

Since $\partial L/\partial A \; I_2^e(A) + \alpha(A)\partial I_2^e/\partial A$

$$= \frac{\alpha(E(r)-i) - (r_a-i)}{I_2^e} I_2^e + \alpha(A)(E(r)-i)$$

$$= -(r_a - i)$$

and since $\partial\beta/\partial A \; I_2^u(A) + \beta(A)\partial I_2^u/\partial A$

$$= \frac{\beta(E(r)-i) - (r_b-i)}{I_2^e} I_2^e + \beta(A)(E(r)-i)$$

$$= -(r_b - i)$$

and since $-r_b + i + \pi(r_b - E(r)) = E(r) + i$

and since $\partial s/\partial A = r_a - E(r)$,

(28) becomes:

$$\partial L/\partial A = pU_a \left[\frac{i(1+i)}{2+i}(E(r) - i) + E(r) + i\right]$$

$$+ (1-p)U_b \left[\frac{i(1+i)}{2+i}(E(r) - i) + E(r) + i\right] > 0 \tag{29}$$

as long as $E(r) > i$.

Thus, with insurance when the rate of return on investment is greater than the interest rate, the limiting factor in increasing production is the level of total assets.

(29) is basically the same condition derived for the self-financing case (27).

Now let us look at the case where debt-financing is available without insurance. We can produce the first order condition for the no-insurance case by removing the insurance component from (28), i.e., $\partial s/\partial A$ and $\pi \partial s/\partial A$. With this modification, (28) becomes:

$$\partial L/\partial A = pU_a \left[\frac{i(1+i)}{2+i}(E(r) - i) - r_a + i \right]$$

$$+ (1-p)U_b \left[\frac{i(1+i)}{2+i}(E(r) - i) - r_b + i \right] \gtrless 0 \qquad (30)$$

Remembering that in this case $U_a \neq U_b$ and $r_a > i$ and $r_b < i$, there are some cases where the first term could be negative even though $E(r) > i$. The first term of (30) could be larger than the second term, depending on the relative probabilities and the shape of the utility function. Therefore, it is possible, even with constant return to scale technology, that utility will decline as the total investment is increased through debt-financing. In other words, risk preferences can limit the use of credit. An example of this was provided in Figure III-5.

The Impact of Insurance on the Supply of Credit

As we will see in the next chapter, crop credit insurance arose not in response to the demands of farmers, but

as mechanisms to control the effects of loan default on small farmers oriented credit institutions. Because of the imperfections in credit markets, the rural poor are often not able to borrow to meet subsistence needs (Nisbet, 1967, 1971). Under such circumstances, it is neither surprising nor socially inappropriate that farmers choose to default on loans. The most severe problems are caused by crop failures, although glutted markets resulting in very low product prices can cause financial problems for non-subsistence oriented farmers.

Crop credit insurance can be very effective in controlling loan defaults which arise from the inability to repay the loan and interest due to poor yields. Since loan defaults decapitalize the credit program, the effect of crop insurance is to increase the supply of credit and lower interest rates. This, in turn, will increase the use of credit at the farm level. We will now develop models of these effects.

Suppose there is an agricultural bank which can obtain capital from the State at interest rate i. The purpose of the bank is to allocate as much capital as possible to socially desirable, credit-worthy borrowers while insuring its ability to continue providing this service in the future. The bank must attempt to lend as much as possible while losing as little as possible through defaults. The

benefit of lending is $(1+\rho)$ for each dollar loaned, where ρ is the gross rate of return. The bank will set the interest rate at $k > i$.

Suppose that the State will subsidize the administrative costs of the bank. Thus, in order for the bank to repay its creditors at the end of the lending cycle,

$$k = i + (1+i)d(L) \tag{31}$$

where k is the default adjusted lending interest rate,

i is the risk free interest rate, and

d(L) is the default rate as a function of the quantity loaned; $d'(L) > 0$.

The demand for credit by farmers will be conditioned by the interest rate charged. Let the demand function for credit be $L_D = D(k)$, where $D'(k) < 0$.

Since the bank is a public institution, there is no reason that it ought to be risk averse. Thus, the managerial problem of the bank can be represented by:

$$\max J = (1+\rho)L - (1+k)L + \nu[L - D(k)] \tag{32}$$

where the first term is the gross social benefit, the second term is the opportunity cost and the third term is the market equilibrium condition, supply equals demand. We can remove the third term by substituting D(k) for L.

Also since $k = i + (1+i)d(L)$, (32) becomes:

$$\max J = (1+\rho)D(k) - (1+i)D(k) - (1+i)d(D(k))D(k) . \tag{33}$$

The first order conditions of (33) are:

$$\partial J/\partial L = \tag{34}$$

$$[(1+\rho)-(1+i)]\ \partial D/\partial L - (1+i)\ [\frac{d(D(k))}{r} D(k) + \frac{D(k)}{r} d(D(k))] =$$

$$(\rho-i)D'(k)d'(L) - (1+i)[d'(D(k))D'(k)d'(L)D(k) + D'(k)d'(L)d(D(k))]$$

since $\partial D(k)/\partial L = \partial D/\partial k \cdot \partial k/\partial L = D'(k)d'(L)$. Removing the $D'(k)d'(L)$ factor from all terms and setting (34) equal to zero, we have:

$$(\rho-i) - (1+i)[d'(D^*(k))D^*(k) + d(D^*(k))] = 0. \tag{35}$$

Since $D^*(k) = L^*$, (35) becomes:

$$\frac{\rho-i}{1+i} = d(L^*) + d'(L^*)L^* = \frac{\partial[d(L^*)L]}{\partial L} \tag{36}$$

The left hand side of (36) is a constant, the present value of the net rate of return on loaned capital. At optimality, this quantity will equal the default rate plus the marginal change in the level of default (the level of loaned capital times the marginal change in the default rate), which is the change in the total quantity defaulted given a change in the level of lending. Since $0 \le d(L) \le 1$, $d'(L)$ must also be bounded by zero and one. The optimal level of

lending is implicitly defined by (36).

Clearly, an auxiliary program like crop insurance which can reduce the default rate and/or the rate of change in the default rate will lead to an increase in the optimal level of lending. Other measures, such as a better production technology, will raise ρ and thereby the optimal level of lending. Without specifying the shape of $d(L)$, we cannot make any judgements on what course might be most beneficial.

It is a reasonable empirical hypothesis that crop insurance will lower the level of default, because farmers will not have to choose between subsistence consumption and loan repayment when crop failure occurs. As we saw in Chapter 2, the relative riskiness of the income stream increases as the debt/equity ratio rises (II-12). One might expect the default rate to be proportional to the debt/equity ratio. Thus, given fixed equity, as the farmer takes on more debt, the debt/equity ratio increases, leading to an increasing default rate.

As an example, let the default rate be:

$$d(L) = \varepsilon(L/Q)\,\psi(L) \tag{37}$$

where

$\varepsilon(L/Q)$ is the debt/equity default magnification factor, $\varepsilon(0) = 1$;

$\psi(L)$ is the functional relationship between the level of lending and the default rate.

Now if both L and Q rise proportionately, the change in the default rate is:

$$\left.\frac{\partial d(L)}{\partial L}\right|_{L/Q = \text{constant}} = \varepsilon^* \psi'(L) \tag{38}$$

where $\psi'(L) > 0$.

Now if debt increases with the level of equity fixed, we have:

$$\partial d(L)/\partial L = 1/Q[\psi(L)\varepsilon'(L/Q)] + \psi'(L)\varepsilon(L/Q) \tag{39}$$

where $\varepsilon'(L/Q) > 0$. (39) is greater than (38) by $[\psi(L)\varepsilon'(L/Q)]\ 1/Q$.

Crop credit insurance has the effect of reducing the risk magnification effect of changes in the debt/equity ratio, i.e., setting the debt/equity ratio to zero, at least for those cases where crop failure covered by the insurance is the cause of default. This would mean that if the default rate is a constant proportion of the level of lending, then:

$$d(L)_{\text{insured}} = \varepsilon(L/Q)\psi(L) = 1 \cdot \psi(L) = \psi(L) \ ,$$

which implies:

$$\partial d(L)/\partial L = d'(L) = \psi'(L) . \tag{41}$$

This would allow us to rewrite (36) as:

$$\frac{\rho-i}{1+i} = \psi(L^*) + \psi'(L^*)L^* . \tag{42}$$

Without insurance, the same conditions would be:

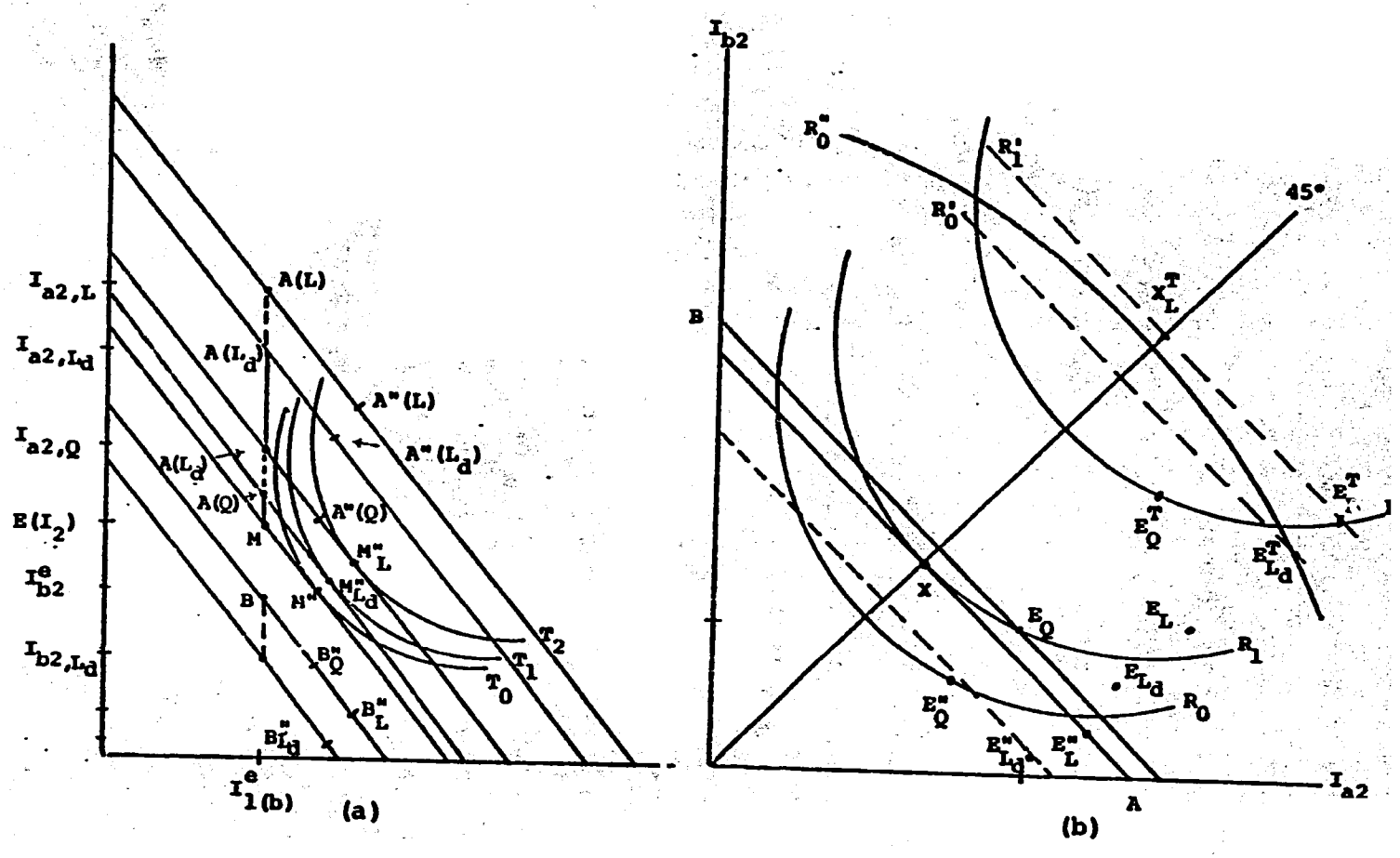
$$\frac{\rho-i}{1+i} = \varepsilon(L^*/Q)\psi(L^*) + [\psi'(L^*)\varepsilon(L^*/Q) + \frac{1}{Q}\varepsilon'(L^*/Q)\psi(L^*)]\ L^* . \tag{43}$$

Clearly, L^* is greater with insurance, given the same gross rate of return and opportunity cost of capital. Thus, one of the benefits of a crop credit insurance program we would expect is that the supply of credit will increase as a result of the control of defaults.

The repercussions of the inability to control defaults can be seen in Figure III-6. While many agricultural banks can, and do, receive subsidies from their sponsoring governments to cover defaults, we will look at the case where the bank is relying on its own resources. Thus, defaults lead to one of two consequences: the interest rate must rise or the bank must reduce its lending rate (decapitalization). The effects on the farmer is roughly the same; the maximum attainable income is reduced.

In Figure III-6a, we reproduce the problem presented in Figure III-5a, where credit facilitates technical

FIGURE III-6


$I_{a2,L}$
I_{a2,L_d}
$I_{a2,Q}$
$E(I_2)$
I^e_{b2}
I_{b2,L_d}
$I^e_{1(b)}$
(a)
A(L)
$A(L_d)$
$A''(L)$
$A''(L_d)$
$A(L_d)$
A(Q)
$A''(Q)$
M
M''_L
M''_{L_d}
M''
B
B''_Q
B''_L
B''_{L_d}
T_2
T_1
T_0
I_{b2}
B
R''_0
R'_1
R'_0
45°
X^T_L
E^T_Q
E^T
$E^T_{L_d}$
X
E_Q
E_L
R_1
E_{L_d}
R_0
E''_Q
E''_{L_d}
E''_L
A
I_{a2}
(b)

change in agriculture. With crop insurance, loan defaults are controlled and Period 2 debt-financed income can rise from point A_q (self-financing) to A_ℓ. Without crop credit insurance, defaults will cause a reduction in lending and/or an increase in the interest rate, resulting in a lower attainable income through debt-financing, represented by point $A_{\ell d}$.

In Figure III-6b, we see that the risk optimization consequences of loan default control. Points E_q and E_q'' represent, as before, the current and present value of second period self-financed income, respectively. Points E_ℓ and E_ℓ'' represent the current and present value of debt-financed insured income, respectively. Lastly, $E_{\ell d}$ and $E_{\ell d}''$ are the current and present value of debt-financed uninsured income. When we add in the optimal first period income for each financing option, we have points E_q^t, E_ℓ^t, and $E_{\ell d}^t$ corresponding to the present values of total income with self-financing, insured debt-financing and uninsured debt-financing, respectively.

Without insurance, self-financing, E_q^t, is preferred to uninsured debt-financing, $E_{\ell d}^t$, and even marginally superior to the default-free uninsured debt-financing, E_ℓ^t. With insurance, point X^t is attainable with debt-financing, and this is preferred to all the other options. This is

an obvious and unremarkable result, given the results of our previous analysis.

Default control does offer benefits, however, to individuals with other kinds of risk preferences. Since defaults control leads to greater lending, producing higher levels of expected income, the risk neutral individual will benefit. We see in Figure III-6b that the indifference curve R_0' is achieved with uninsured debt-financing, while indifference curve R_1' can be reached with insurance.

Even the mildly risk-seeking individual can be better off with insurance. Let indifference R_0'' represent the preferences of a mildly risk seeking person. Such a person would prefer insured to uninsured credit. If a moderately efficient gambling scheme were available, even the individual with pronounced gambling preferences will choose insured credit, if the effect of defaults on the credit supply is great enough.

Since defaults are not restricted to risk averse individuals, one can expect the supply-side impact of crop credit insurance to extend to all types of borrowers. The supply-side effects of crop credit insurance are even broader than those on the demand side.

CONCLUSIONS

Two important theoretical conclusions emerge from this chapter. First, risk averse individuals may be induced to accept credit as a result of the risk reducing effects of crop credit insurance. Thus, to the extent that there are many risk averse farmers who are potential clients of agricultural credit programs, there will be a significant shift in the demand for credit upon the introduction of crop credit insurance.

Second, to the extent that crop credit insurance can reduce loan defaults, there will be an increase in the supply of loanable funds. This will benefit even those individuals who would not purchase insurance on an individual, non-compulsory basis, if loan funds are being rationed. Thus, crop credit insurance may make agricultural credit available to persons who would not otherwise have benefited from it irrespective of their risk preferences.

CHAPTER 4

AN INSTITUTIONAL ANALYSIS OF CROP CREDIT INSURANCE IN THE AGRICULTURAL CREDIT SYSTEM

Introduction

In the last two chapters, we approached a variety of issues relating to the economics of crop credit insurance using the standard graphical and mathematical models of economic analysis. In order to expand our range of analysis to understand the role of crop credit insurance within a broader institutional and political structure, we will need a more flexible modelling technique. The technique to be employed here is oval diagramming (Delp, et al., 1977, pp. 82-90), which is an extension of graph theory applied to qualitative systems analysis. We will begin our analysis by "translating" the major components of the economic model of crop credit insurance into an oval diagram. We will then expand that model to include a broader set of institutional, financial and policy variables. This analysis does not discard the core economic model developed in Chapters 2 and 3, but rather it will show how the economic model is conditioned by policy decisions and institutional relationships. Having laid a general framework, we will then proceed to examine the available information on the crop credit insurance programs in Mexico and Panama.

A Reformulation of the Crop Credit Insurance Model

Consider the case of a simple economy of one consumer with a utility function $U(q_1, \ldots, q_n)$, where there is an implicit production function $F(q_1, \ldots, q_n, x_0)$ and a fixed supply of one primary factor of production, x_0, not desired by the consumer. The Pareto optimal necessary conditions for such an economy are obtained by maximizing the consumer's utility function subject to the production function. The problem is stated as:

$$\max L = U(q_1, \ldots, q_n) - \lambda F(q_1, \ldots, q_n, x_0), \quad (1)$$

which gives the following first order conditions:

$$\partial L/\partial q_i = U_i - \lambda F_i = 0 \quad ; \quad i = 1, \ldots, N . \quad (2)$$

The relationship which characterizes the optimal state is:

$$U_i/U_j = F_i/F_j \quad ; \quad i,j = 1, \ldots, N . \quad (3)$$

Assume that institutional factors prevented the attainment of one of the conditions in (2), such that:

$$U_n - \gamma F_n = 0 , \quad (4)$$

where $\gamma \neq \lambda$, and λ is the optimal value of the marginal increase in gross production. Given such a constraint, the new optimization problem for the consumer becomes:

$$\max J = U(q_1,\ldots,q_n) - \lambda F(q_1,\ldots,q_n,x_0) - \delta(U_n - \gamma F_n) \ . \tag{5}$$

Deriving the first order conditions of (5), we have:

$$\partial J/\partial q_i = U_i - \lambda F_i - \delta(U_{ni} - \lambda F_{ni}) = 0 \ ; \ i = 1,\ldots,n \tag{6}$$

and

$$\partial J/\partial \lambda = - F(q_1, \ldots, q_n, x_0) = 0 \tag{7}$$

and

$$\partial J/\partial \delta = - (U_n - \gamma F_n) = 0 \tag{8}$$

Since a solution to this system of equations where $\delta = 0$ would reduce (5) to (1), we can readily see that the conditions characterizing optimality are no longer (3), but:

$$U_i/U_j = \frac{\lambda F_i + \delta(U_{ni} - F_{ni})}{\lambda F_j + \delta(U_{nj} - F_{nj})} \tag{9}$$

Since it seems unwarranted to make any <u>a priori</u> assumptions about the cross-partial derivatives U_{ni}, U_{nj}, F_{ni}, F_{nj}, there is no reason to believe that the normal Pareto optimal conditions (3) will hold for any pair of commodities, $q_1, \ldots, q_n$. In such a situation, it would be suboptimal to implement a public policy to achieve the

Pareto optimal conditions appropriate for a perfectly competitive market. If the cross-partial derivatives in (9) were to be close to zero, meaning that neither the production nor the enjoyment of product i and j were affected in any important manner by product n, then the Pareto optimal necessary conditions will hold in a piecemeal fashion.

The argument just developed is known as the Theory of the Second Best. Succintly, the Theory of the Second Best states: "if one or more of the necessary conditions for Pareto optimality cannot be satisfied, in general it is neither necessary nor desirable to satisfy the remaining conditions (Henderson and Quandt, 1971, pp. 286-288).

In Chapter 2 and 3, we have engaged in partial equilibrium analysis, based on the implicit assumption that all of the linkages between farmer and/or bank and the rest of the economy meet the Pareto optimal conditions. We assumed perfect capital markets and perfect markets for farm products and production inputs. As we examine the agricultural credit systems in Mexico and Panama in this chapter, it will become clear that most of the economic relationships between farmers and their product, factor and financial markets are affected, if not governed, by institutional forces.

The fact that political and social forces "interfere" with the functioning of economic markets is hardly a reason to ignore economic analysis. As we compare the "interfered" model presented in (5) with the "pure" model in (1), it should be obvious that we will be able to say very little about the behavior of the "interfered" economy if we only analyze the institutional constraint $\delta(U_{ni} - \gamma F_{ni})$. On the other hand, the Theory of the Second Best demonstrates that if we ignore the institutional factors we are almost certain to produce a biased analysis of the behavior of the economy.

What follows in this chapter is an attempt to do both. We have laid ground work for the behavior of the farmer and the agricultural bank in a world free of institutional intervention. We will now develop a model which will incorporate the institutional constraints and the social and political forces which affect the behavior of an agricultural credit system.

To develop this model, we will employ the techniques of oval diagramming. In oval diagramming (Delp, et al., 1977, Chp. 7), ovals represent variables. Arrows indicate the direction of hypothesized causation, and the sign on the arrowhead determines whether the relationship changes from direct to inverted or vice versa over some

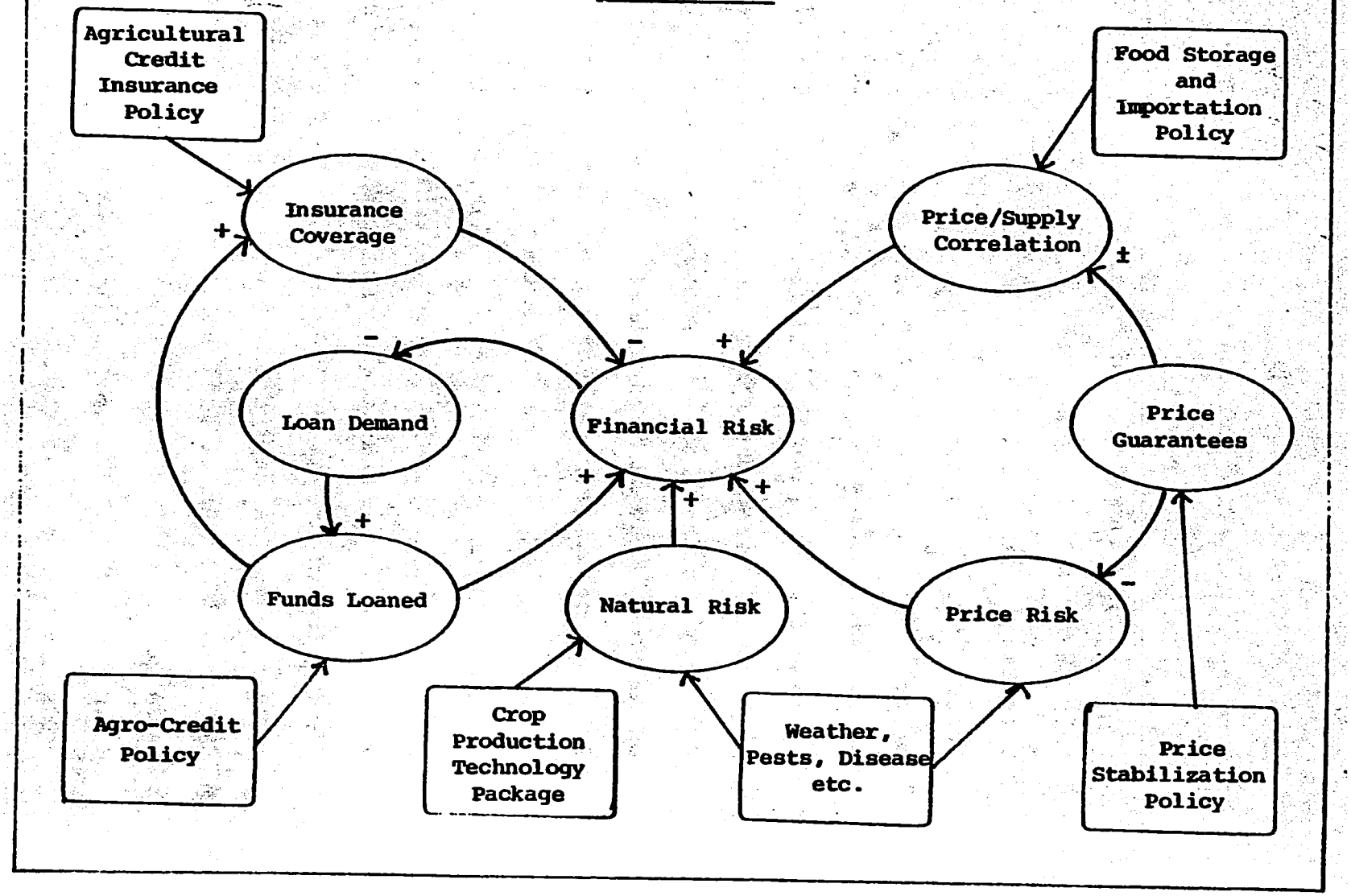
range of the variable. A loop is a sequence of arrows which lead out of and return to the same node (variable). The sign of a loop is determined by multiplying the signs of all the arrowheads in the loop. A negative loop indicates that the process modelled by the loop tends to stability (the level of the variables do not increase or decrease to positive or negative infinity). A positive loop is explosive.

We will begin our analysis with a subset of the agricultural credit system which is most relevant to the economic model of crop credit insurance developed in the last two chapters. In Figure IV-1, the reformulation of the crop credit insurance model is presented.*

Let us begin with the exogenous variables Weather-Pests-Disease. These factors cause Natural (yield) and Price (market) Risk. Price Risk is also negatively affected (decreased) by Price Guarantees which are determined by the Price Stabilization Policy. Price Guarantee, as we saw above, will also have an impact on the Price/Supply Correlation, which in turn affects Financial Risk. The same is true of Food Importation Policy, which affects Financial Risk through the Price/Supply Correlation. Agri-

*Variables in this and subsequent models will be capitalized in the text.

FIGURE IV-1


Agricultural Credit Insurance Policy
Food Storage and Importation Policy
Insurance Coverage
Price/Supply Correlation
Loan Demand
Financial Risk
Price Guarantees
Funds Loaned
Natural Risk
Price Risk
Agro-Credit Policy
Crop Production Technology Package
Weather, Pests, Disease etc.
Price Stabilization Policy
+
-
±

cultural Credit Policy will determine the supply of public funds available for agricultural credit. This in combination with Loan Demand will determine the Funds Loaned. As Funds Loaned increases, so the debt/equity ratio at the farm level will increase; this in turn will lead to an increase in Financial Risk. On the other hand, as Funds Loaned increases, the total Insurance Coverage will increase. The effect of the insurance, ceteris paribus, is to stabilize income which will decrease Financial Risk.

In the oval diagramming approach to systems analysis, the crucial relationships which determine system behavior are found in the "loops". A loop is a sequence of variables which feed back on themselves. In Figure 1, there are two loops. First there is the loop which begins with Financial Risk, which goes through Loan Demand and Funds Loaned and returns to Financial Risk. Notice that the product of the signs -- (-)(+)(+) = (-) -- is negative. A negative loop tends toward stability; in the case at hand, Financial Risk will eventually be increased through higher levels of debt from Funds Loaned, such that Loan Demand will begin to fall and the subsystem (loop) will come to rest. The second loop goes from Financial Risk to Loan Demand to Funds Loaned to Insurance Coverage back to Financial Risk. The sign of this loop is positive --

(-) (+) (+) (-) = (+). Considered by itself, this loop is unstable, since the Ideal Insurance Coverage would completely offset the risk magnifying effects of the growing debt/equity ratio. The double loop subsystem does not become unstable because Agricultural Credit Policy places an upper limit on Funds Loaned. Also, since the insurance coverage is limited by deductibles, the second positive loop will probably not offset the first negative loop as the average debt/equity ratio grows very large. It is interesting to note that system stability is achieved through the exogenous variables; policy intervention (capital budgets at the bank and deductibles on the insurance policy) keep the systems from becoming unstable.

Before moving on to a much more elaborate model of Figure IV-1, it is well to emphasize a few points learned in the preceding analysis. First, the basic characteristics of the microeconomic model of crop credit insurance are embedded in Figure IV-1 and will be somewhat more fully modelled in Figure IV-2. Second, while the economic model is helpful in explaining the dynamics of the system depicted above, the state in which the system finds itself at any moment is to a very considerable degree determined by exogenous factors, such as climate, the state of technology and a host of official policies. Lastly, it is

clearly possible that the great variety of official interventions may work against each other in unforeseen and unbeneficial ways.

The Systems Perspective and Crop Insurance Research

It is sometimes possible to look at institutions and processes independently of the environments in which they exist -- in economic theory, this is known as partial equilibrium analysis. This kind of analysis is only valid in the case where market equilibrium is Pareto optimal, under which condition social and private optimality are coincident, and all decisions can be made in a decentralized manner without jeopardizing social welfare. When we relax these assumptions about market perfection, we are in the world of the Second Best.

Clearly rural capital markets do not satisfy first order Pareto optimality conditions, or at least this is the nominal justification for the existence of publically subsidized agricultural credit programs for small farmers -- programs which crop credit insurance is designed to support. By extension of the theory of the second best, it is neither necessary nor desirable that a crop credit insurance program be financially viable or privately efficient in order that it generate a net social benefit. The net

social benefit of crop credit insurance can only be judged in terms of the contribution which it makes to the entire agricultural credit system. This contribution could well involve the need for heavy subsidization of insurance rates. The crop insurance agency may be bearing costs generated by other institutions.

Criticisms that crop insurance is too expensive (Roumasset, 1976; Gomez, 1976) are based on the narrow evaluation of crop insurance, as though it were a publically owned counterpart of a private insurance firm. It will not be surprising that such evaluations are often negative. and usually misleading.

Crop Insurance in the Agricultural Credit System

There are five major official institutions which play a role in an agricultural credit system. First, we have the Ministry of Agriculture which establishes the kind of crops to be funded, the regions where they can be grown and the production technology to be employed. Of all of the possible insurable crops, it is the principal role of the Ministry of Agriculture to define the technically feasible subset of crops which are eligible for official credit.

Next, we have the price stabilization agency which sets price floors or price guarantees for certain crops,

especially basic grains which are often grown by small farmers. This same price stabilization agency may also be responsible for the determination of consumer prices. The determination of an effective price guarantee defines the subset of economically feasible crops which can receive official credit. Crops whose gross revenues (price times yield) do not exceed production costs are not likely to receive credit, except where there is a deliberate subsidy policy. Thus, the combined effect of the determination of crop technology and prices is to define the subset of technically and economically feasible crops eligible for official credit. Also, in nations where basic foodstuffs are being imported in large enough quantities to affect the market price of agricultural products, food importation policies must also be considered as a factor which influences economic feasibility.

The agricultural bank, of course, plays the central functional role in this system, but in many cases the decisions on the allocation of public funds to agricultural credit it made in the Treasury Ministry. The Treasury's decision on bank operating capital and interest rates further limits the subset of economically and technically feasible crops to the subset which is also financially feasible. Given all of these constraints, the bank is able to select from the group of farmers willing to borrow

at the stated interest rate to cultivate the designated subset of feasible crops. It is usually the case that the bank is faced with a capital budgeting problem; since interest rates are subsidized, demand exceeds the supply of loanable capital.

It is only now that the crop credit insurance agency enters the picture, now that the subset of technically, economically and financially feasible crops has been determined (probably without any significant consultation with the crop insurance agency). Furthermore, the portfolio of potential policyholders has already been selected by the bank, when it decided to loan to particular individuals and groups. Since the insurance is obligatory, the insurer is obliged to offer it to all the bank's clients. It does have a limited ability to redefine the subset of feasible crops to those which are insurable, and it can select out certain individuals from its portfolio on the ground of technical deficiencies in the crop or moral hazard. By and large, it is forced to accept the portfolio selected by the bank.

The only parameter over which the crop insurance agency has control is the premium rate. However, the premium rate, like the interest rate and the price guarantee, has proven to be a sensitive political issue,

especially because of the compulsory nature of the insurance. Thus, in practice crop insurance agencies tend to feel limited in their ability to adjust premium rates to cover their losses. It is common to find in these insurance agencies some crops having loss ratios considerably in excess of one and others with very low loss ratios. An attempt is made to balance the losses on one crop with the surpluses of others. Thus, while the whole operation may require subsidies, a large number of policyholders may be paying actuarially unfair premiums.

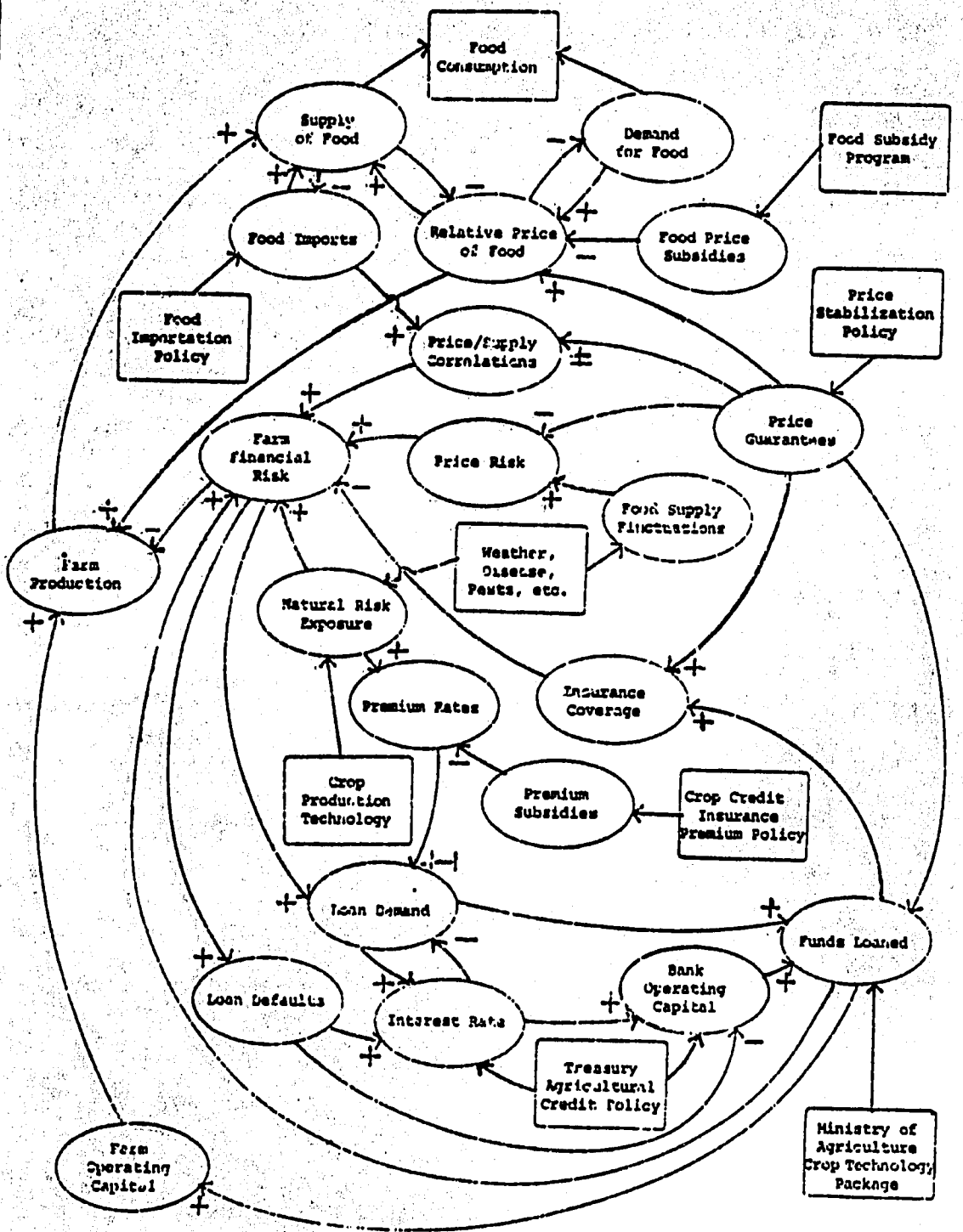
In summary, we see that most of the important decisions about the kind of crops and the kind of policyholders are made not by the insurance agency, but rather by the other institutions of the agricultural credit system.

A General Model of the Agricultural Credit System

In Figure IV-2 is presented a model of the agricultural credit system in a developing country. The first step in the institutional analysis of an agricultural credit system is to determine the policy making apparati for the following policies: Food Importation, Food Price Subsidies, Agricultural Product Price Stabilization, Treasury Agricultural Credit Policy, Ministry of Agriculture Crop Technology Packages, Bank Lending Criteria, and

FIGURE IV-2

CROP CREDIT INSURANCE IN THE AGRICULTURAL CREDIT SYSTEM



Insurance Premium and Coverage Limits. One needs to know what these policies are, who participates in policy formation and what information serves as the basis of policy analysis.

Having determined these various policies and how they are implemented, we are ready to study how they directly and indirectly affect the crop insurance program. Beginning with Treasury Agricultural Credit Policy in the lower portion of Figure IV-2, we see that Bank Operating Capital and Interest Rates are directly determined here. However, the Interest Rate directly affects Bank Operating Capital. Bank Operating Capital along with Loan Demand directly affects Funds Loaned, which is also influenced by the Ministry of Agriculture Crop Technology Package (technical feasibility) and the Price Guarantees (economic feasibility).

Increasing Funds Loaned in the context of obligatory insurance has three separate impacts. First, by raising Farm Operating Capital, it leads to an increase in Farm Production. Secondly, by increasing the indebtedness of farmers, it increases Farm Financial Risk, which in turn affects the willingness to borrow, thereby decreasing Loan Demand. Lastly, Funds Loaned will increase Insurance Coverage, which will decrease Financial Risk, thus increasing Loan Demand. If the insurance is actuarially

fair, then the premiums collected will equal compensation payments over the long term, and thus there will be no direct disincentive effect from the insurance. As a practical matter, increasing Insurance Coverage usually entails the expansion of the credit system and insurance programs to more marginal farmers, which means that average Premium Rates will rise, especially when risky and secure farmers are mixed for premium rate determination. This, in turn, leads to a decline in Loan Demand, but only after some relatively high threshold is reached -- the bars around the sign of the arrow signify a threshold effect. This is due to the capital rationing nature of the credit system; Interest Rates are lower than their market equilibrium levels, and thus Premium Rates are not much of a disincentive until this Interest Rate level is exceeded. Furthermore, through Insurance Premium Policy, the Treasury can counteract this disincentive by means of Premium Subsidies.

Stabilization Policy also has a direct impact on crop credit insurance. The Price Guarantees which result from the Stabilization Policy determine, in part, the upper limit of Insurance Coverage on a per hectare basis. Since the Insurance Coverage cannot exceed gross revenue, the Price Guarantee determines the upper limit on coverage in conjunction with yield estimates. Stabilization also

reduces Financial Risk, and thus when used in conjunction with insurance, a considerable reduction in income variability. Food Importation Policy can also affect crop insurance indirectly by changing the Supply of Food; these connections come through the interaction between Food Subsidy and Price Guarantee Policies.

This picture is complicated by the effect which Price Guarantees and Food Imports have on the natural relationship between agricultural prices and yields. If prices and yields were negatively correlated in a free and closed agricultural market, Food Imports and Price Stabilization could actually raise the level of Financial Risk to the farmer.

The model presented in Figure IV-2 incorporates all of the behaviors which were suggested by the partial equilibrium models of the farm and the agricultural bank in Chapters 2 and 3. We will now proceed to set forth the crucial public policies followed by the governments of Mexico and Panama in the late 1970's.

The Case of Mexico

Mexico represents the most mature case of crop insurance in the developing world, besides being a large program by any standards. With the recent introduction of the

Mexican Food System (Sistema Alimentario Mexicano - SAM), some major changes are in store for the entire agricultural credit system. The analysis presented here will concentrate on the credit system as it existed in the latter half of the 1970's. For background on the credit system before this, see Silos and Chazano, 1976; Carnajal and Bajonero, 1976; Niembro, 1976; Rosales, 1974, 1977; and Carrillo, 1976. We will then briefly review the goals of the newly implemented Mexican Food System with its goal to integrate policy intervention by the various official institutions of the agricultural credit system.

1. Institutional Structure for Subsidizing Agricultural Credit in Mexico

BANRURAL

The Banco Nacional de Crédito Rural (National Bank of Rural Credit) was formed in 1975 by a merger of the Banco Nacional de Crédito Agrícola (National Bank of Agricultural Credit) and the Banco Nacional Agropecuario (National Agricultural and Livestock Bank). BANRURAL operates entirely with public funds in all areas of the country. If offers two types of credit: short term production loans (credit de avío) and long and medium term capital investment loans. The short term production loans represent the major part of BANRURAL's portfolio and are the

focus of our interest here. Loans have been made at fourteen percent interest and are based on crop programs. The crop programs are designed by the Instituto Nacional de Investigaciones Agrarias (National Institute of Agrarian Research); these specifications are then passed to the local irrigation or rainfed farming district officer of the Secretaria de Agricultura y Recursos Hidraulicos (SARH - Ministry of Agriculture), who must approve the programs on the basis of technical feasibility. These programs are then submitted to BANRURAL and ANAGSA, the crop insurance agency, who must also approve them. At the district level, SARH, BANRURAL and ANAGSA hold a public meeting where local, regional and national farmers' organizations and farm labor unions may, and do, challenge items in the crop programs.

CONASUPO

A major element in the crop programs are the estimates of gross revenue for particular crops. BANRURAL cannot set a loan limit above the expected revenue of the crop. The estimate of gross revenue is based, in part as mentioned above, on the expected physical production established by INIA in its crop experiments and surveys; the same is true of the specifications for cultivation prac-

tices, physical inputs, labor use and factor prices. The other determinant of gross revenue is product price. In the case of basic grains, where most of the subsidization effort seems to be directed, the Compañia Nacional de Subsistencias Populares, S.A. (CONASUPO - National Staple Co.) establishes each year guarantee prices for all basic grains (Grindle, 1977). The guarantee operates not by regulating market prices, but rather CONASUPO guarantees to purchase all grains of a specified quality delivered to one of its warehouses (there is now an extensive network). This tends to put a floor on local market prices: the CONASUPO price minus transportation costs.

The price guarantee made by CONASUPO is incorporated into BANRURAL's crop programs. Thus, CONASUPO is determining which of the technically feasible elements of BANRURAL's portfolio are economically feasible. As far as we know, the question of technical feasibility is made independently of the determination of the price guarantee. Consequently, it would be wrong to assume that the technological package recommended by SARH is the one that will maximize profits once the price guarantee is known.

ANAGSA

The Aseguradora Nacional Agrícola y Ganadera, S.A. (National Agricultural and Livestock Insurance Agency)

provides insurance to farmers who receive loans from BANRURAL. The coverage of the insurance policy is equal to the amount loaned by BANRURAL, and with some exceptions compensation payments are made directly to the bank when a claim is approved. This insurance is obligatory for short term loans, and the policy constitutes a form of collateral for the loan. The premiums collected from the farmers run from seven to fifteen percent of the loan principal and are discounted from the loan in most areas. There is generally a large subsidy of five to fifty points, e.g., the actuarially fair premium rates are as high as sixty percent but the farmer pays only ten percent. The premium rate subsidy for ejido land is universally higher than that for private land for the same crop and for the same agroecological zone.

Agricultural Subsidy Policy: Secretaría de Hacienda y Credito Público

Overall subsidy policy is determined by the Ministry of the Treasury and Public Credit (Hacienda), which acts as the budgeting agency for BANRURAL and ANAGSA; the Minister of Treasury sits on the CONASUPO executive board as chairman. There does not appear to be an overall agricultural credit policy which is based on considerations of technical feasibility, economic feasibility and rate of

return on public capital. The process of rationing capital to agriculture is determined by CONASUPO and the technical feasibility of agricultural production in the various regions of the country. In short, even in implicit terms there is no evidence that agricultural credit policy is designed to optimize either agricultural income or the rate of return on agricultural credit.

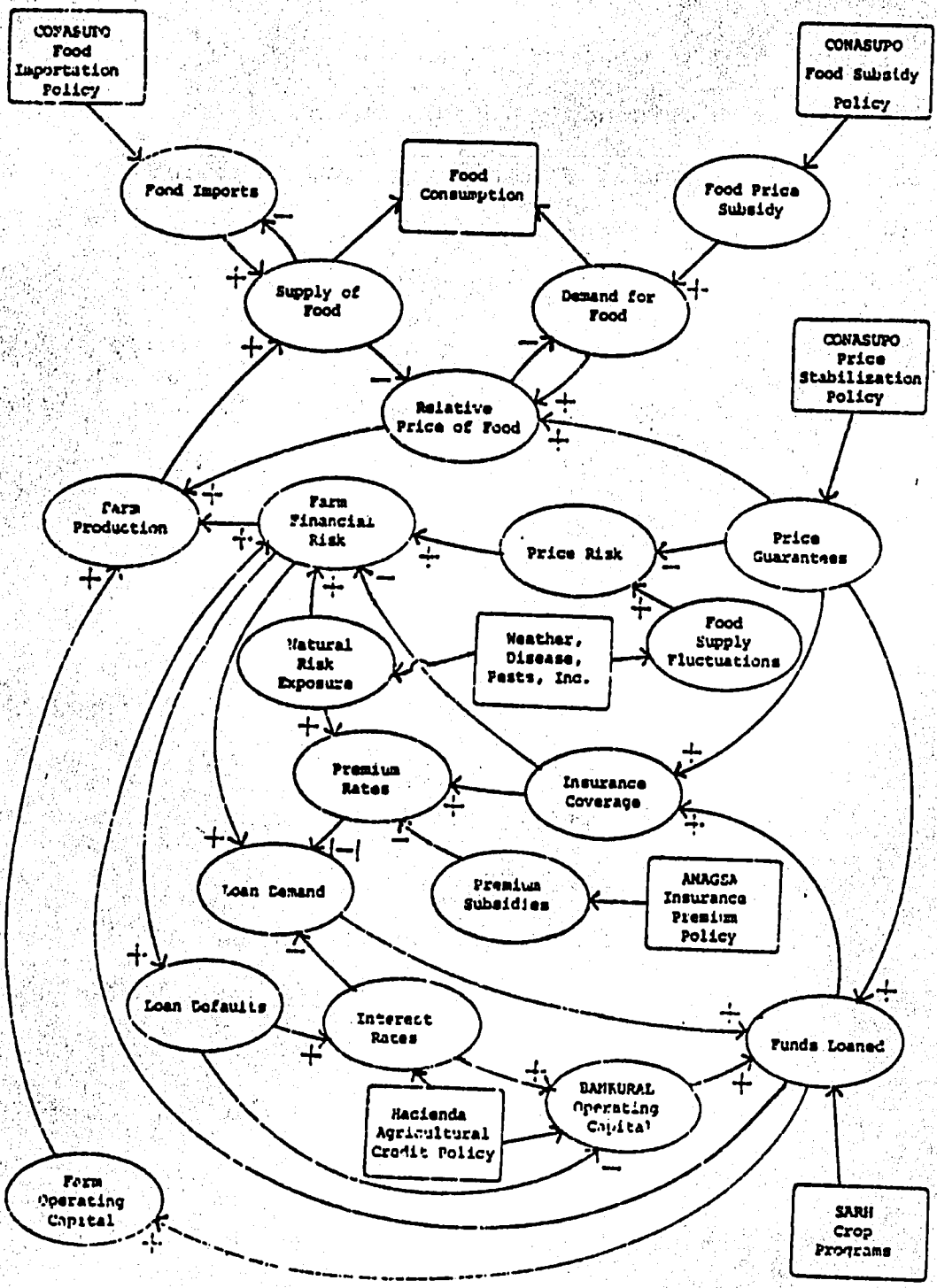
2. Mexican Agricultural Credit: A System Perspective

We will now employ the technique of oval diagramming to describe the series of relationships which result from the subsidy policies of the institutions described above. In Figure IV-3, we present a model of the relationships of the Mexican Agricultural Credit System.

We begin by looking at those variables which affect Farm Production directly. Most important are the Relative Prices of farm products, in terms of our interest here, the Relative Prices of foodstuffs. As the Relative Price of Food goes up, Farm Production will increase, which will in turn increase the Supply of Food, which will reduce the Relative Price of Food. This loop has three segments, two positive and one negative, which produces a negative loop (+)(+)(-) = (-). As mentioned before, a negative loop tends toward equilibrium.

FIGURE IV-3

MEXICAN AGRICULTURAL CREDIT SYSTEM



The Relative Price of Food in Mexico is not determined by market forces only. CONASUPO intervenes in the market guaranteeing price floors for producers and subsidizing food consumption for low income consumers. CONASUPO also imports foods, increasing the Supply of Food and thereby lowering Relative Food Prices (Higler, 1980). This may also change the supply/price correlation. We do not know if CONASUPO's Price Floors are above or below the market Price of Food. To urban consumers, CONASUPO claims to have lowered the Price of Food for the low income family, while with farmers it claims to offer a fair price, one superior to that obtainable in the private market. Lastly, by guaranteeing a price floor, irrespective of the level, CONASUPO reduces the Price Risk faced by the farmer, which in turn reduces Financial Risk which is inversely related to Farm Production. Thus, we have a positive loop from Price Guarantees to Farm Production (-)(+)(-) = (+). Therefore, CONASUPO's effect on agricultural production is ambiguous - Food Imports decrease prices and thereby Farm Production. Price Floors reduce risk but they may or may not represent an adequate economic incentive. CONASUPO has also changed the natural correlation between prices and yields. These policies have been in place so long now that the question of the natural price/yield correlation is merely hypothetical.

An indirect effect of CONASUPO's price policy on Farm Production relates to the variable, Funds Loaned. CONASUPO's Price Guarantee helps determine the economic feasibility of BANRURAL crop loan programs; the number of feasible loans will increase, increasing Funds Loaned, ceteris paribus, which in turn increases Farm Operating Capital and Financial Risk. Increasing Operating Capital will increase Farm Production, but increasing Financial Risk will decrease Production. These relationships will be discussed again in terms of crop insurance.

Moving backwards from Farm Production to Farm Operating Capital to Funds Loaned (a positive loop), we can see the effects of Hacienda Subsidy Policy on Farm Production. Hacienda determines the Interest Rates which will be charged on official loans and the Operating Capital of BANRURAL. Since BANRURAL interest rates are several points below those of large private banks and perhaps as much as twenty points below those of traditional moneylenders, the demand for loans always exceeds the supply. Thus, BANRURAL is faced with a capital budgeting problem. Its potential portfolio is restricted to a technically feasible set by SARH and to an economically feasible set (in the case of basic grains) by CONASUPO's price guarantees. BANRURAL then offers loans according to its percep-

tion of national production goals and social justice. It is clear, in terms of the second goal, that many ejidos are not economically viable and many more cannot use public credit as productively as other sectors. Yet, the policy of the Mexican government is to support the ejido system for reasons to be discussed below.

Increasing Funds Loaned has two effects. One is to increase Operating Capital and thereby increase Farm Production. The other is to increase Financial Risk. Financial Risk is composed of three elements: Price Risk, Natural Risk, and the debt/equity leverage position of the farm enterprise. Price Risk refers to the fact that farmers do not know at the time they begin the agricultural production cycle what the price of the product will be. Natural Risk refers to the variability in the yields obtained due to forces beyond the farmer's control. Price Risk and Natural Risk combine to make gross farm income vary. To the extent that the farmer must borrow to produce a particular level of income, the income that is left becomes more and more variable. This is due to the fact that the debtholder must be repayed no matter how unsuccessful the crop; thus, all of the variability in gross farm income is shifted to the equity holder. This combined effect is called Financial Risk, and it increases as the quantity of Funds Loaned increases; its effect is to

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reduce Farm Production wherever f ers are risk averse, As Financial Risk rises, i.e., the debt/equity ratio increases, the likelihood that any particular farmer will default on his or her loan, due to a bad harvest or low prices, also increases. This would lead either to the decapitalization of the bank and/or an increase in Interest Rates.

Two steps have been taken to control defaults. First, CONASUPO fixes Price Guarantees which when combined with the technical feasibility of the crop loan programs guarantees that prices will never drop so low that default is necessary. Second, each borrower is required to take an insurance policy with ANAGSA which eliminates the need for defaults in the case where yield drops so low that the loan cannot be repayed. This brings in the other way in which Hacienda affects agricultural credit. As Natural Risk exposure increases, Premium Rates must also go up. Hacienda provides ANAGSA with funds to subsidize premiums. As Premium Rates rise, the demand for loans will go down, which will decrease funds actually loaned. The bars around the sign on the arrowhead signify that the effect is realized only when the level of the causing variable reaches a certain threshold. In certain regions of the country, loan funds are so scarce that it would seem that

Premium Rates could hardly ever reach levels where the demand for essentially rationed funds would decline. In other cases, to be discussed below, the demand for BANRURAL loans has been affected. We note that CONASUPO's Price Guarantee Policy has a direct impact on ANAGSA's total coverage, which is a specified percentage of gross revenue, varying according to production technology. Lastly, it is an empirical fact that the recent expansion of the Mexican agricultural credit system has been greatest in marginal areas. Thus, as loans rise, the average or typical debt/equity ratio increases. As Insurance Coverage increases in these areas, higher total Premium Rates are necessary, or conversely, greater Premium Subsidizes are required per peso of coverage extended.

The effect of the crop insurance is to decrease Financial Risk, thereby indirectly increasing Farm Production and decreasing Loan Defaults, which would indirectly lower Interest Rates and increase the Bank Operating Capital. If the insurance scheme is actuarially fair, long run farm income will be unchanged; the risk averse farmer should be happier with such an insurance scheme, while the risk neutral (profit maximizing) farmer will be indifferent

3. <u>The Social Functions of Crop Credit Insurance</u>

From the preceding discussion, we see that many decisions about crop insurance are made by institutions

other than ANAGSA. The total coverage is set by the joint decisions of SARH and CONASUPO on expected gross revenues. The actual portfolio of insurance policies is selected by BANRURAL when it decides who will receive agricultural credit. Only premium rates are under the complete control of ANAGSA. We saw in Figure IV-3 that, on average, premium rates must rise dramatically to affect loan demand, although there are notable exceptions. We will now move to a discussion of ANAGSA's premium rate setting policy.

Premium Rates

ANAGSA has been using a very simple rate setting procedure. The premium rate for each crop using a specified technology in each agroecological insurance zone is calculated by dividing the total compensation payments for the past three years made for the crop by the total coverage for the past three years. This is the total premium rate. The lowest total premium rates run about 10% and correspond to commercial crops in the irrigated northwest. The highest total premium rates come close to 60% and are found associated with maize cultivated on rainfed ejido land by indigenous farmers in Oaxaca.

This rather straightforward way of calculating the premium allows us to see clearly the subsidy policy which is being followed. The total premium rate is divided into

two parts, that paid by the insured and that paid by the government. The premium rate for the farmer hardly ever exceeds 15%, and we found no case where it surpassed 20%. There is almost no crop insurance program which does not involve some subsidy, with the highest-risk, most marginal farmers receiving the greatest relative subsidies. As an example of the type and level of subsidization, we present Table 1 -- data on unfertilized rainfed maize in 1979. This is the technologically least sophisticated crop covered by insurance, and it is closely associated with marginal, indigenous farmers. We see that the average premium is 33.42%, with the ejidatario paying only 9.55% and the smallholder paying 13.36%. The level of subsidization for basic grains is much higher than for industrial crops, particularly cotton; thus, the total subsidy levels for the entire ANAGSA portfolio will be less than what is presented here. Based on this same data, it was found that the total premium rate and the average plot size insured were negatively correlated ($r = -.31$, $t = -2.31$). Also, one ought not confuse the relative with the absolute subsidy level. For example, in Tapachula, Chiapas, the total premium rate on rainfed cotton is 12.90%, of which the government pays 4.2% for ejidos and 3% for smallholders (see Annex I). Given a total coverage of Me$ 14240 per ha.,

TABLE IV-1

DATA ON UNFERTILIZED RAINFED CORN INSURED BY ANAGSA IN 1979

OFFICE CODE	COVERAGE PER HA.	YIELD/ HA.	TOTAL PREMIUM	INSURED PREMIUM	INSURED PREMIUM	PLANTING COST/HA.	INSURED PER CLIENT	% HAS. SMALLHOLD
31	652	450	58.29	11.33	14.35	200	1.05	12.91
31	870	600	58.65	11.53	14.35	200	1.32	16.51
31	1720	1300	57.59	10.90	13.95	200	1.19	0.00
31	1475	1100	57.59	10.90	13.95	-	1.32	0.00
27	1450	1000	41.70	7.85	11.35	100	1.29	0.00
15	1450	1000	37.44	10.63	14.90	140	-	26.71
17	2170	1500	31.78	7.64	11.56	180	-	5.29
33	1740	1200	28.19	8.25	11.21	230	2.79	8.47
21	870	600	23.90	10.82	14.03	150	2.22	0.00
28	1450	1000	17.34	7.86	11.06	225	6.01	12.24
40	1882	1300	23.56	10.69	14.41	200	4.67	34.95
22	1450	1000	22.45	8.54	13.27	120	15.63	29.98
25	940	650	43.55	8.90	12.45	150	0.04	100.0
25	870	600	44.19	9.28	12.79	150	2.94	19.42
33	1740	1200	28.26	8.29	11.06	230	3.35	7.76
32	290	200	39.49	11.72	15.30	50	3.26	12.34
34	895	629	60.15	10.51	5.96	100	1.92	13.04
30	1202	900	41.93	9.10	13.95	110	0.90	0.00
30	1595	1100	40.55	7.30	13.10	360	1.31	0.22
30	1450	1000	38.92	7.48	14.46	150	4.05	0.82
30	2553	1800	38.63	7.51	14.40	200	2.78	2.27
12	2550	1800	29.04	9.96	13.00	300	1.01	16.19
06	580	400	21.27	9.53	14.05	113	1.10	8.30
06	725	500	21.28	9.58	14.05	200	2.19	8.32
14	2000	1400	27.00	11.23	14.76	150	-	16.47
16	1880	1300	23.07	11.69	14.65	125	2.99	10.85
16	1510	1050	21.70	10.42	14.00	125	6.29	0.00
01	2320	1600	25.48	13.87	17.45	150	2.37	21.36
41	652	450	38.02	10.12	13.33	-	7.06	8.00
41	580	400	38.51	10.63	13.36	135	1.71	2.07
42	2158	1500	42.77	8.57	14.38	426	0.90	23.07
42	1739	1000	43.21	8.85	14.71	225	1.04	0.54
42	1218	700	41.97	8.10	13.70	200	3.32	0.00
02	1016	1000	25.60	7.45	11.70	300	0.32	0.00
02	1800	1400	26.33	8.01	12.33	225	23.83	28.93
02	1636	1200	26.74	8.32	12.51	300	0.52	12.86
09	1015	800	28.70	8.30	11.60	100	2.18	6.67
43	2465	1700	32.93	10.97	17.70	200	0.60	2.02
44	1810	1250	23.33	9.09	13.62	200	1.72	33.14
24	1595	1100	24.82	8.67	11.52	105	4.58	3.17
03	1450	1000	20.00	9.59	12.70	100	3.40	2.74
08	1500	1050	23.40	11.25	14.10	150	1.09	0.00
35	1160	800	50.82	10.21	13.02	150	0.40	5.82
35	580	400	31.25	10.05	14.35	150	0.76	0.00
35	725	500	54.53	12.47	15.90	150	0.85	2.15
35	1230	850	30.85	9.81	13.54	150	1.66	6.37
35	2175	1500	20.05	9.36	13.24	150	0.66	11.81
36	1247	860	21.03	8.92	11.34	150	5.13	7.92
07	1885	1300	17.95	7.95	12.00	225	1.99	0.00
07	1885	1300	17.69	7.66	11.60	150	3.67	13.51
07	1150	1000	22.22	11.75	15.75	250	4.93	11.42
07	1595	1100	18.27	8.33	12.72	220	5.66	0.00

CORRELATIONS:

(Has. per insured) and (Total Premium Rate)	- .31	t = -2.31
(Coverage per Ha.) and (Has. per insured)	.08	
(% Has. Smallholder) and (Total Premium)	01	

SOURCE: ANAGSA, 1979b

this is a subsidy of Me$598.08 and Me$427.20 per acre for ejidos and private land respectively. The projected average plot size was 5.88 has. per farmer, giving Me$3513.72 subsidy to the ejido and Me$2509.80 to the smallholder. On the other hand, in nearby Tuxtla Gutierrez district of Chiapas, a rainfed fertilized corn program provided a 18.6% subsidy for ejido farms (9.10% paid by the farmers), but the average plot size was only 2.99 has. and the coverage Me$3480.00, giving a Me$647.28 per acre and a Me$1935.37 total subsidy. Lastly, we have the case of a special program with the Instituto Nacional Indigenista in the tropical rain forest of northern Chiapas where average plot size is 1/3 ha., the total coverage Me$1016.00 per ha., with a premium subsidy of 18.15%, giving a Me$184.40 per ha. and Me$59.01 per farmer subsidy.

In Table 1, the reader will have noticed that the smallholder universally pays a higher premium rate than the ejidatario; this is true for all crops in all insurance zones. This redistributive policy receives its justification from the fact that on average private holdings are larger than ejido holdings and private farmers are richer than ejido farmers. There are, of course, many exceptions to this rule; the case of ejido cotton farmers in the Tapachula district is a valid one. This differential

subsidy policy is a clear indication of the government's support of the ejido system.

Another form of redistribution rests on the geographic distribution of the subsidies, wherein certain regions of the country receive higher rates of subsidy than others. Generally, areas like Morelos, Oaxaca and the states of the central plateau are more highly subsidized. These are the areas where strong peasant organizations and movements existed during the agrarian reform; they appear to have learned how to effectively make demands on the agricultural credit system.

In the aggregate, we can see evidence of these policies by looking at ANAGSA's crop cycle data. In Table IV-2, we present data from ANAGSA's winter cycle. The winter cycle is comprised largely of irrigated crops, principally industrial crops like cotton or vegetable crops for export or canning. It is interesting to note the evidence of policy shifts in this series, especially evident in the loss ratio column. Here we see that in 1976 a definite shift took place with the Lopez Portillo administration which greatly reduced the loss ratio compared to previous years. In Table IV-3, we have the data on the summer cycle, the rainfed crops which includes most of the ejido land and the indigenous farmers. Here the loss

TABLE IV-2

ANAGSA WINTER CYCLE

Cycle	Area Insured (1)	No. of Insureds (2)	Insured Premium (3)	Compensation Payments (4)	Insured's Expected Benefit (4)/(3)	Compensation/ha. (4)/(1)	Compensation per Insured (4)/(2)	Premium per Insured (3)/(2)
63-64	465180	192150	20128587	13553705	.673	29.14	70.54	104.75
64-65	458675	188016	15845246	21985903	1.388	53.44	116.94	84.28
65-66	486672	213881	19198027	24085994	1.255	50.54	112.61	89.76
66-67	486604	213612	21651954	24334693	1.124	113.92	113.92	101.36
67-68	393555	49673	23283847	73813697	3.170	187.56	1485.99	468.74
68-69	383831	56186	27396407	41521545	1.516	108.74	739.00	487.60
69-70	400201	49563	26262529	37703343	1.436	94.21	760.72	529.88
70-71	486830	54813	31000661	45491295	1.467	93.44	829.94	565.57
71-72	423903	57208	30656432	42126355	1.374	99.38	736.37	535.88
72-73	357941	47423	26915374	43974309	1.634	122.85	927.28	567.56
73-74	481748	77641	42838834	21601263	.504	44.84	272.22	551.76
74-75	693207	104993	76207478	97701699	1.282	140.94	930.55	725.83
75-76	1060835	151050	128305287	278291148	2.169	262.33	1842.38	849.42
76-77	1098710	148563	176094541	139909302	.795	127.34	941.34	1185.32
77-78	1077234	122159	322500000	237422096	.736	220.40	1943.55	2640.00
TOTAL	8755126	1726931	988282145	1143516358				
AVE.					1.157	130.61	662.17	572.28
GRAND TOTAL	32552596	7653952	4247000490	7805101343	1.838	239.76	1019.75	554.88

SOURCE: ANAGSA, 1979a

TABLE IV-3

ANAGSA SUMMER CYCLE

Cycle	Area Insured (1)	No. of Insureds (2)	Insured Premium (3)	Compensation Payments (4)	Insured's Expected Benefit (4)/(3)	Compensation/ha. (4)/(1)	Compensation per Insured (4)/(2)	Premium per Insured (3)/(2)
64	1028902	143942	71983788	120456768	1.673	117.07	836.84	500.09
65	1057297	136033	78957741	130492665	1.653	123.42	959.27	580.43
66	1005448	162410	73127904	159403362	2.180	158.54	981.49	450.27
67	954407	149829	73206646	162221390	2.215	169.97	1082.71	480.08
68	1189692	377237	83685861	164041860	1.960	137.89	434.85	221.84
69	1154472	399981	72258613	243343913	3.369	210.78	608.39	180.66
70	1381931	384283	85186067	235805724	2.769	170.63	613.63	221.62
71	1413758	469252	96794989	166230749	1.717	117.17	354.25	206.28
72	1306418	430185	100768583	236713414	2.349	181.19	550.26	234.24
73	1568797	497450	123610748	139292684	1.127	88.79	280.01	248.49
74	1787708	685020	254864307	664728249	2.609	371.83	970.38	372.05
75	2896122	535631	379067474	1136177161	2.997	392.31	2121.19	707.70
76	2438301	549496	350575211	1245527533	3.553	510.82	2266.67	637.99
77	2545709	477909	665231509	889134962	1.332	349.27	1860.47	1391.96
78	2068508	528363	676271000	968014551	1.431	467.98	1832.10	1279.94
TOTAL	23797470	5927021	3258718345	6661584985				
AVE.					2.044	279.93	1123.93	549.81

SOURCE: ANAGSA, 1979a

ratios have always been much higher, although the trend to reduce the loss ratio with the coming of the actual administration is still clearly evident. It seems clear that recently, at least, larger, private, commercially-oriented farmers have been paying actuarially unfair premiums as a group. Thus, real income redistribution has been taking place within the agricultural credit system.

A last complication arises from the way in which premium rates are set. As mentioned above, the premium rate is merely the sum of three years compensation payments divided by the sum of three years of coverage for a particular crop in a given agroecological insurance zone. Obviously, this premium rate is actuarially fair only for a farmer with an average set of losses over the last three years. The better than average farmer would be paying too much. With the premium rate subsidy, the effective premium rate is lowered. However, it seems that certain agroecological insurance zones are heterogenous enough that significant numbers of farmers feel they are being charged too much. The best known case is that of the area around the city of Puebla, where the post-graduate college of the National School of Agriculture has been carrying out an agricultural development program since 1968. There has been a continuing controversy about the premium paid by the participants in the project. Studies by Plan Puebla

show the loss ratio of these farmers to be below 1 (CIMMYT, 1974). It seems that Plan Puebla farmers, working mostly to the west of the city of Puebla are being averaged in with farmers from south of the city, where the crop production conditions are much more marginal. ANAGSA shows significant losses for the region as a whole, but really is not prepared to analyze claims performance on a much finer geographical basis. It seems clear that this must occur in virtually every insurance zone, but that greater homogeneity plus the subsidy reduces the problem to a level where complaints are not widespread. At some point, however, those farmers who are paying too much may opt to leave the official credit system. There has been a marked increase for uninsured loans requested by Plan Puebla farmers from the Banco Nacional de Mexico, which does not have an agreement with ANAGSA (CIECADAR, 1978). Although BANCOMER (Banco de Comercio) operates in Puebla, its operations have not expanded much, since it does require ANAGSA insurance. BANRURAL has only barely maintained its portfolio of Plan Puebla farmers. This may lead, in the long run, to the kind of adverse selection that one hopes to avoid with obligatory insurance. The best farmers are being driven out of the system by the disincentive of the insurance rates, and the marginal farmers are being attracted due to the subsidy. There is

some evidence of this in the case of Puebla, where the percentage of Plan Puebla farmers using formal credit rose from only 12% to 16% in ten years (CIECADAR, 1978). Plan Puebla officials claim that farmers use credit and insurance to adopt the new technology and to learn to use it effectively. After a few years, they tend to drop out of the formal credit system and use self-financing and traditional sources of credit to finance their operations.

In Table IV-4, we summarize the subsidy and redistributive functions of crop credit insurance in Mexico. Clearly, some of the redistributive measures are more than cancelling the incentive effect of the premium subsidies for certain groups of farmers; unfortunately, they are likely to be the most progressive farmers, and where they are not large farmers, as in the case of Plan Puebla, the net effect of these conflicting policies may be to exclude them from formal agricultural credit.

Administrative and Supervisory Services

ANAGSA maintains its central office in the capital, Mexico City. The overall programming and budgeting, as well as the actuarial calculation, is conducted at this level. The field operations are decentralized into twelve regional offices which are now able to process compensa-

TABLE IV-4

SUBSIDY, REDISTRIBUTION AND SUPERVISION FUNCTIONS OF CROP INSURANCE IN MEXICO

	SUBSIDY	FUNCTIONS REDISTRIBUTION	SUPERVISION
NATIONAL	48% of ANAGSA budget subsidy Ministry of Treasury; partially to subsidize premiums, partially to subsidize administration, partially to subsidize supervision.		INIA determines ANAGSA's feasible crop portfolio; BANRURAL determines production costs, setting coverage levels. ANAGSA determines set of insurable crops.
REGIONAL		Premium subsidy for farms in central plateau vis-a-vis other areas. All risk insurance biased toward central plateau: food insurance for the desert and drought insurance for tropical rain forest.	
LOCAL		Within agroecological zone all insureds raising same crop pay same premium. Premiums calculated on basis of performance on all farms in the zone, thus redistributing premium expenses to marginal farmers.	ANAGSA and BANRURAL often share supervisory responsibilities.
SOCIAL ORGANIZATION OF PRODUCTION		For the same crop in the same agroecological zone, ejidatarios pay a smaller premium than the smallholder.	
CROP CYCLE	Since 1976 Winter cycle premiums exceed compensation and most of the administrative costs.	Premium relative to risk much higher for winter cycle; generally larger commercially oriented and irrigated farms.	Supervision appears to be superior for winter cycle.

tion payments. Each region is broken into several districts. The district director is the person who represents ANAGSA in the programming meeting with BANRURAL and SARH. Each district is divided into corresponsalias which are collections of agroecological insurance zones organized mostly in terms of the feasibility of supervision. The district office is also a corresponsalia.

Each corresponsalia has one or more supervisors who deal directly with the farmers. These supervisors are all agronomists, and their understanding of the economic or statistical theory of insurance is barely superior to that of the educated layman. Their role is not to assess risk but rather to manage it by insuring that farmers cultivate the insured crop according to the technical specification agreed on by SARH, BANRURAL and ANAGSA. It might seem unnecessary that both ANAGSA and BANRURAL maintain independent and essentially duplicate supervisory staffs. It is thought in ANAGSA that without independent supervision, the insurance would be exploited to cover the inadequacies of the supervision and the bad loans of BANRURAL.

The farmer is essentially neutral to the issue of duplication of supervision, since this is not included in the premium. The insurance does, however, offer an extra supervisory mechanism by which farmer behavior can be made

to conform to institutional expectations. BANRURAL, when it encounters a farmer who is not following the specified cultivation practices, can cancel the loan. In doing so, it may make it impossible for the farmer to grow a successful crop, and thus it faces an almost certain default. ANAGSA, on the other hand, looks at the same farmer in a completely different light; by deviating from the specified cultivation practices, the farmer is increasing the probability of a claim. Thus, it is to ANAGSA's benefit to cancel the policy. Cancellation of the policy is a real penalty, since the farmer will lose at least part of the premium and he will be exposed to a greater risk than before, but cancellation of the policy does not guarantee failure the way cancellation of the loan does. Of course, BANRURAL is usually unhappy about such events, since their probability of default rises, but they may be able to recover if they supervise closely. Also, in the case of partial damage, ANAGSA supervisors have the right to specify that certain steps be taken. When these steps involve more of the materials provided by the loan, the bank is obligated to increase the loan to the farmer to cover these costs. If they are not undertaken, the policy can be cancelled.

This kind of supervision makes crop insurance very expensive. It is as though an automobile insurance company

had to monitor the traffic enforcement operations of the police in order to keep the number of accidents down. Such a system is thought to be necessary in Mexico because the effectiveness of overall supervision is enhanced by the ability to cancel the insurance policy without cancelling the bank loan. It is believed that if the insurance operation were incorporated into the banking operation the conflict created by the cancellation of the insurance policy would be resolved in favor of the banking function, resulting in no further insurance policy cancellations. This would diminish the effectiveness of the supervisory system and make the insurance scheme financially completely unviable. We will return to this issue in the next chapter

Criticisms of Mexican crop credit insurance as being too expensive (Gomez, 1976) have not taken into account the very expensive supervisory role which crop credit insurance performs on behalf of the agricultural credit program. Much of this supervisory cost would more appropriately be assigned to the credit program, not the insurance scheme. In so far as some of the costs of running ANAGSA result from deficiencies in BANRURAL's own supervision, the cost of crop credit insurance is overestimated in Mexico.

4. Consequences of the Lack of Managerial Control

From the discussion above, we see that ANAGSA's inability to influence key decision parameters leads to a situation in which its institutional viability as an insurance program is compromised. The most important of these consequences are the inability to control administrative costs, the inability to adequately diversify its portfolio of policies and the dimunition of the insurance function relative to the subsidy function.

Administrative costs can be divided into two parts. The processing costs associated with a policy (paperwork) and supervision of the insured. By far the latter is the more expensive. This is unfortunate since there seems to be ample room to reduce the burden of paperwork through streamlining and electronic data processing (this process is now underway), but supervision is likely to become even more burdensome as increasingly marginal groups of farmers are incorporated. At the operational level, several measures have already been taken. BANRURAL field staff often fill in for ANAGSA staff and vice versa; this is an informal arrangement and must be done with some discretion since BANRURAL and ANAGSA sometimes have conflicting interests. Nevertheless, in cases where no damage is reported, this seems a workable expediency. In the case of INI clients,

ANAGSA very often abrogates all supervision to INI, i.e., no germination inspection and no damage inspection. From ANAGSA's point of view, this is a pure subsidy operation. Lastly, ANAGSA simply fails to inspect some inaccessible policyholders. Since there are limits to which these expediencies can offer greater cost reduction in supervision without provoking a massive increase in moral hazard claims, ANAGSA's administrative costs are largely determined by the portfolio of loans which BANRURAL asks it to insure; these kinds of costs are increasing at a disproportionate rate as the Treasury Ministry is authorizing more funds for marginal farmers.

By the same token, ANAGSA has little managerial control over the diversification of the portfolio of policies it must extend. We see that the way in which claims arise from the different types of policies has an important impact on overall portfolio variability. BANRURAL has, as an institution, little interest in and no information upon which it could incorporate the impact of its portfolio selection on ANAGSA's financial viability.

Lastly, it should be noted that while premium rates are not as sensitive politically as interest rates, they certainly can be considered inflexible. Were collected premium rates to rise close to their actuarially fair

level, organized groups of farmers (through organizations like the National Confederation of Peasants, National Confederation of Small Farmers, etc.) would quickly bring political pressure to bear. Thus, collected premiums rate adjustments are not a viable solution to the insurer's financial viability. Another avenue of limited benefit which ANAGSA seems to have undertaken might be called "fine print adjustment". These adjustments of policy conditions allow ANAGSA to reject more policy requests, cancel more policies or avoid or reduce compensation payments under specified conditions. While not really unreasonable, these fine print adjustments cause resentment, and special cases where they appear to be especially arbitrary are the favorite examples for ANAGSA's critics. Again, the benefits are marginal, and they must be so since too much success in this approach will cause BANRURAL to react, since such escape clauses will directly affect its default rate.

5. Agricultural Credit, Insurance and SAM

In a shift away from the emphasis on financial viability of agricultural credit and related institutions, the government of Lopez Portillo has recently implemented the Sistema Alimentario Mexicano (SAM - Mexican Food System).

The plan is very broad in scope, and we will focus only on those parts which affect the agricultural credit system. (See Oficina de Asesores 1980, Banco Nacional de Comercio Exterior 1980, Critica Politica 1980).

In 1980, ten pilot regions were selected and the following changes will be implemented:

1) The prices of fertilizer and seed charged to BANRURAL borrowers are dramatically reduced.
2) The interest rate charged is lowered from 14% to 3%.
3) The premium rate charged is lowered from 10-15% to 3%.
4) In the case of partial coverage crop programs*, the insurance policyholder will receive an income subsidy equivalent to 40% of the loan principal in case of loss.

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*At the beginning of the Lopez Portillo administration, a new series of partial coverage loan programs were created to allow BANRURAL to reach a greater number of farmers with the same capital. Full coverage loans encompassed all production costs, including labor. Thus, in many cases a smallholder or ejidatario would receive cash from the bank to hire labor, when he would actually work the land himself. The value of labor has been a major controversy at the crop loan program meetings because SARH uses figures which it feels approximate the value of the marginal product product of labor. Ejido and smallholder organizations want the minimum wage to be used. The new programs of partial coverage generally include only the cost of selected inputs, such as fertilizer, seeds or pesticides; labor costs are usually not included.

The effect of the SAM is to expand the stated loan and coverage levels, allowing even more marginal farms to reach the economic and technical feasibility criteria. At the same time, the costs of credit and insurance are reduced, thereby increasing the demand for loans. Lastly, BANRURAL's operating capital was increased by 50% over the 1979 levels. Thus, the overall level of subsidization has increased substantially in the pilot areas. Presumably, these policies will be gradually extended to the entire country. Obviously, the need to finely adjust premium rates to loss behavior is even less important than previously; the subsidy function dominates even more than the insurance (risk-spreading) functions.

THE CASE OF PANAMA

Panama is a small country with slightly less than two million people. Because of the Panama Canal, the Panamanian economy is somewhat less dependent on agriculture than other Latin American nations. The crop credit insurance law was enacted in December of 1975, and full scale operations began in the spring of 1977. During the 1979-80 agricultural production cycle (the latest available), the Instituto de Seguro Apropecuario (Agricultural and Livestock Insurance Institute - ISA) issued 1284

policies for crop insurance covering 13988 hectares. Compared with Mexico, where ANAGSA in the 1977-78 production cycles issued 60,055 policies covering 4,636,471 hectares, ISA is a small program, roughly equivalent in scale of operation to the ANAGSA regional office for the states of Chiapas and Oaxaca, where the author did his field work. In spite of the changes in scale and the differences in the economic structures of Mexico and Panama, there exist many remarkable similarities between ISA and ANAGSA. This is partly due to the fact that ANAGSA was used as a model for ISA. Even more importantly, the similarity in the institutional structures in which the crop insurance agency must operate is leading ISA to repeat many of the steps through which ANAGSA has already evolved.

1. The Institutional Structure for Subsidizing Agricultural Credit in Panama

BDA

The Banco de Desarrollo Agropecuario (the Agricultural and Livestock Development Bank) is the principal source of official agricultural credit in Panama. The BDA loans funds at a discount rate of 13% to a variety of borrowers. Most BDA clients are individual farmers, but loans are also made to agricultural production cooperatives and

agrarian reform collectives (asentamientos). This last group is the result of the agrarian reform program of the late 1960's and early 1970's, which was undertaken by the government of Gen. Omar Torrijos. The asentamientos are nominally collectives, but many have become disorganized into little more than groups of independently operating farms. The BDA's experience with both groups has not been very good, and in many cases the BDA has refused to work with these groups as groups and instead makes loans directly to individual members. Many of these groups are still technically in default on outstanding loans made in the first half of the 1970's. Accurate data on the BDA's operations are very difficult to obtain. Even direct inspection of the bank records (performed by members of the ISA-IICA research team) leaves one bewildered about the default rate and the type of loans made and interest paid. While the BDA supported the idea of a crop insurance agency, recently the director general of the bank has publically criticized the insurance program and has brought pressure to bear on ISA to liberalize its compensation policy. We will return to this issue later.

IMA

The Instituto de Mercadeo Agropecuario (Agricultural and Livestock Marketing Institute) of Panama functions very

much like CONASUPO in Mexico, although its operations are not as extensive. IMA sets price guarantees each year which are used in planning the next crop production cycle. These prices are used in establishing loan and insurance programs. IMA also functions as a crop storage agency, although unlike Mexico, there are frequent reports of storage capacity being exceeded, with the result that farmers are often forced to sell to local traders at prices below the guarantee. Thus, price stabilization has a rather qualified meaning in Panama. Lastly, IMA is responsible for importing foodstuffs which local producers are unable to supply in sufficient quantity -- principally maize, beans and sometimes rice. Again, price stabilization and food importation policies are nominally coordinated with technology, credit and insurance policies, but an adequate understanding of how these policies interrelate seems lacking.

ISA

The Instituto de Seguro Agropecuario (Agricultural and Livestock Insurance Institute) supplies insurance to approximately 80% of the BDA's clients. ISA insures only rice, maize, beans, sorghum and industrial tomato, and it operates in only six of Panama's nine provinces. It has been gradually increasing its coverage of BDA operations

and within another five years will probably reach the almost complete coverage achieved by ANAGSA.

ISA's field operations closely resemble ANAGSA's in that it relies chiefly on agronomists with minimal training in insurance and economics to make field visits. The criteria for approval of the policy are an adequate level of germination, use of approved technology and freedom from imminent disaster. In the area of coverage and compensation payments, ISA differs slightly from ANAGSA. The total coverage level for a crop is the sum of the direct production costs with a 30% deductible. However, when a compensation payment is made, actual production costs are used when these are smaller than the stipulated production costs in the program. Somewhat asymetrically, when an actual production cost is higher than it was projected to be in the crop program, the lower figure is always used. Furthermore, compensation payments are made on the basis of the costs incurred up to the date of the disaster. Since a large proportion of the crop losses come soon after planting, this means that the actual coverage level for most cases where compensation payments are made is only about 50-60% of the total production costs. This has been a sore point, and the BDA recently used its influence to force ISA to pay farmers experiencing complete loss of crop the full value of the insurance coverage. Initial

figures indicate that this is going to have a significant impact on ISA's loss ratios. In this, ISA is facing a situation similar to that faced by ANAGSA in the SAM pilot areas -- insurance is being used as a contingent income transfer, in that the compensation payment will exceed the actual coverage.

ISA's actuarial function is even weaker than ANAGSA's. In Table IV-5, we present the average loss ratios for the first three years of operation along with the premium rates (lower diagonal) by crop and by province. A loss ratio reasonably close to one signifies that the premium rates are reasonably close to being actuarially fair. Here we see the same pattern as in Mexico: some premium rates are much too high (e.g., rice in Chiriqui, Los Santos and Veraguas) and other are much too low (e.g., sorghum in Cocle, Veraguas and Panama). Recently, the premium rates on rice have been lowered and sorghum has been raised, but this has been done across the board and will not address the variability of loss ratios within the crop category.

The administrative costs of ISA run about 6% per dollar of coverage, which makes it slightly larger than the average premium rate (ISA, 1980b). ISA's overall loss ratio is approximately 60% for its crop portfolio and

TABLE IV-5

LOSS RATIOS (LR) AND PREMIUMS (P) FOR ISA: 1977-1980

CROP	PROVINCE:	Chiriqui	Los Santos	Herrera	Cocle	Veraguas	Panama
RICE	LR	.1085	.16		.938	.328	
	P	.06	.06		.06	.06	
MAIZE	LR	1.066	.234	1.158	.275	.878	15.9
	P	.05	.05	.05	.05	.05	.05
SORGHUM	LR	1.304	1.47	1.235	2.78	3.176	2.396
	P	.05	.05	.05	.05	.05	.05
BEANS	LR	2.737					
	P	.07					
TOMATO	LR		.414	.792	.11	4.998	
	P		.07	.07	.07	.07	

SOURCE: Hogan, 1980a

roughly 100% for its livestock portfolio. It receives approximately 147,000 Balboas from the Government of Panama as an administrative subsidy (ISA 1980a) or about two percent of total coverage. Since the livestock portfolio is just breaking even, the rest of the administrative costs (four percent of the total coverage) must come from premiums paid on crop insurance policies). Thus crop insurance is not actuarially fair overall, and from Table IV-5, we saw that premiums for rice (rice representing about 46% of total coverage for crops and 30% for the entire portfolio) is subsidizing the other crops and the livestock insurance. Again, as in Mexico, we find that unsophisticated actuarial practices are supporting income redistribution within the agricultural sector. The notable difference in Panama is that the level of direct subsidy to ISA is very much smaller (two percent versus 48% in Mexico). The law which created ISA in article 12 (ISA 1978) guarantees one million Balboas (dollars) initial capital. These funds have never been delivered and ISA considers the million dollars as a kind of a guarantee or reinsurance against a nationwide disaster which would bankrupt the insurance fund. Even so, the guarantee is sufficiently nebulous that ISA feels compelled to operate in such a way as to guarantee its financial viability through its operations. ISA is, then, something fairly close to the kind

of insurance agency envisioned by crop insurance critics -- a publically owned counterpart to a private insurance company. In light of this, it is interesting to compare ANAGSA and ISA in terms of their contribution to their respective agricultural credit systems.

MIDA

The Ministerio de Desarrollo Agropecuario (Ministry of Agricultural and Livestock Development) is responsible for supplying the technical information for the crop programs which will receive official credit and insurance. The MIDA takes a somewhat more predominant role in overall agricultural sector credit planning than is the case in Mexico. MIDA is also responsible to provide the technical assistance to credit users, and it has the responsibility for the creation and continuing support of the agrarian reform asentamientos.

Agricultural Subsidy Policy

The Panamanian agricultural credit system does not have a pre-eminent agency or ministry overseeing its operations in the way in which the Secretaria de Hacienda y Credito Publico operates in Mexico. The Ministerio de Industrias y Comercio (Ministry of Industry and Commerce)

has a representative on the ISA board of directors, but its role seems to be to represent the point of view of the broader economy, rather than to supervise and coordinate policy along the lines of Mexico's Hacienda. Thus although smaller and seemingly more manageable, Panama's agricultural credit system seems to suffer more from policy drift and inconsistencies than that of Mexico.

2. Panamanian Agricultural Credit: Some General Considerations

We will not repeat the oval diagramming exercises of earlier sections here, since the results would be virtually identical. However, we will refer back to Figure IV-2 in order to focus the discussion. First, we noted that in Panama the lack of sufficient storage facilities reduces the effectiveness of price stabilization, since government warehouses are frequently unable to accept new shipments of basic grains from farmers, who must then find buyers on the local market, usually offering lower prices. Thus the arrow between Price Guarantees and Price Risk ought to have a "?" rather than a "-". Second, the box, Treasury Agricultural Credit Policy, which affects Interest Rate and Bank Operating Capital is much less coherent than it appears; rather it is a policy arising out of interinstitutional bargaining. To some extent, Crop Credit Insurance

Premium Policy is less well oriented toward general social goals -- in Panama the director general of the agricultural bank does not even sit on the board of directors of the insurance institute. Lastly, it seems likely that at least for the case of rice, the Insurance Premium Rate has reached the threshold where it can become a disincentive to borrowing. Since for many policyholders the insurance premiums are not actuarially fair, the impact of Insurance Coverage on Financial Risk is somewhat diminished. Overall then, it is clear that the effect of insurance on rice cultivation is to increase the level of investment and thereby the level of production. What redistribution is taking place within the agriculture is not oriented by any specific social policy. In its agreement with the Inter-american Institute for Agricultural Sciences (IICA), ISA agreed to put 50% of its coverage into small farm agriculture. IICA and ISA have been tentatively working with a definition of a small farm as an agricultural operation with less than $10,000 total assets, but very little has been done to actually implement the agreement. The clients of the BDA and ISA are ordinarily not among the poorest of the poor -- more typically they are middle class farmers, with the exception of the asentamientos. It is interesting to note that the goal to orient ISA's portfolio more toward small farmers was not even mentioned in the annual report

of the year in which the agreement was signed (ISA 1979, p. 18). From what we know of the role of crop insurance in the agricultural credit system, it was unrealistic to expect ISA to be able to comply with the 50% coverage agreement. The selection of ISA's portfolio is in the hands of BDA. It is the BDA's policy to loan principally to middle class farmers and to back away from its involvement with production cooperatives and asentamientos. Given the central government's lukewarm commitment to subsidize ISA's operations, any move by ISA to dramatically increase its portfolio of small farmer policies could threaten its own financial viability. A significant change in ISA's operating policy must first require a significant commitment at the level of the central government.

Comparing ISA and ANAGSA leads to some significant insights into the case against crop insurance. ISA could easily be run in the black with only minor changes in operating procedures and premium rates. We must, however, question whether ISA would be performing any significant social function. ANAGSA, on the other hand, clearly has made it possible to extend credit to hosts of small farmers and ejidatarios who could not have qualified for credit due to lack of collateral. We wonder, however, if the benefits of the insurance are great enough to justify the heavy subsidization required to keep the program from bankruptcy.

These questions will be raised again in Chapter 5 when we consider the problems involved in evaluating crop credit insurance programs.

METHODOLOGICAL NOTE

The data presented in this chapter was collected while I was employed as a consultant with the Crop Credit Insurance Research Project of the Interamerican Institute of Agricultural Sciences in San Jose, Costa Rica. The Mexican data was obtained principally during a visit to the offices of ANAGSA in Mexico City during the later half of August 1979 (Aubey and Hogan, 1979). I made a subsequent trip to Mexico City in January 1980. There were also two trips to Chapingo and Puebla, the sites of the Postgraduate College of the National School of Agriculture and Plan Puebla respectively in February and April of 1980. While I was working in San Cristobal Las Casas, Chiapas from July 1979 to June 1980, I made several visits to the regional office of ANAGSA in Tuxtla Gutierrez. Visits were also made to the district offices in Tuxtla Gutierrez and Tapachula, Chiapas, and to the corresponsalia in San Cristobal Las Casas. Also, I took the opportunity to observe the operation of BANRURAL and the district office of SARH while in San Cristobal Las Casas.

The Panama data was collected on two trips to Panama City during mid-August and mid-November of 1980, including some time in a provincial office. I also had access to the Panama data file and documents at the Interamerican Institute's headquarters in San Jose during my visit there in July 1980.

CHAPTER 5

GUIDELINES FOR THE EMPIRICAL EVALUATION OF CROP CREDIT INSURANCE

Introduction

In this chapter, the question of determining the empirically achievable benefits of crop credit insurance will be considered. First, we will discuss the major empirical issues to be addressed. Next, we will be considering the problem of generalizing from the available instances of crop credit insurance which can be subjected to an empirical investigation. Lastly, we will discuss the empirical models to be employed in this research. Specifically, we will look at the microeconomic farm model which has been developed and some of the test results produced by it. Some suggestions for modification will be made. Then, we will discuss the model of the agricultural bank. Due to limited resources and the difficulty of interagency cooperation, a simplified approach will be proposed for the empirical research in Mexico and Panama.

Major Empirical Issues

The principal issue in crop credit insurance research is:

1. Does crop credit insurance increase the use of agricultural credit?

If the insurance is actuarially fair, we know from the analysis in Chapters 2 and 3 that an increase in the use of credit when crop credit insurance is made available is evidence that farmers are risk averse. We will discuss below some of the conceptual and practical difficulties which arise when the insurance is not actuarially fair. A positive answer to question 1 does not guarantee that crop credit insurance generates a positive net social benefit. First, we must ask:

2. Does the increased use of agricultural credit generate a positive net social benefit?

It is not impossible that the credit program is so poorly designed that social costs exceed benefits. In the terminology of capital budgeting theory, crop credit insurance is a contingent project; its role is to contribute to the social benefits generated by an independent project -- the agricultural credit program.

If the social rate of return on the additional credit use exceeds the opportunity cost of providing the loan capital, we still must ask:

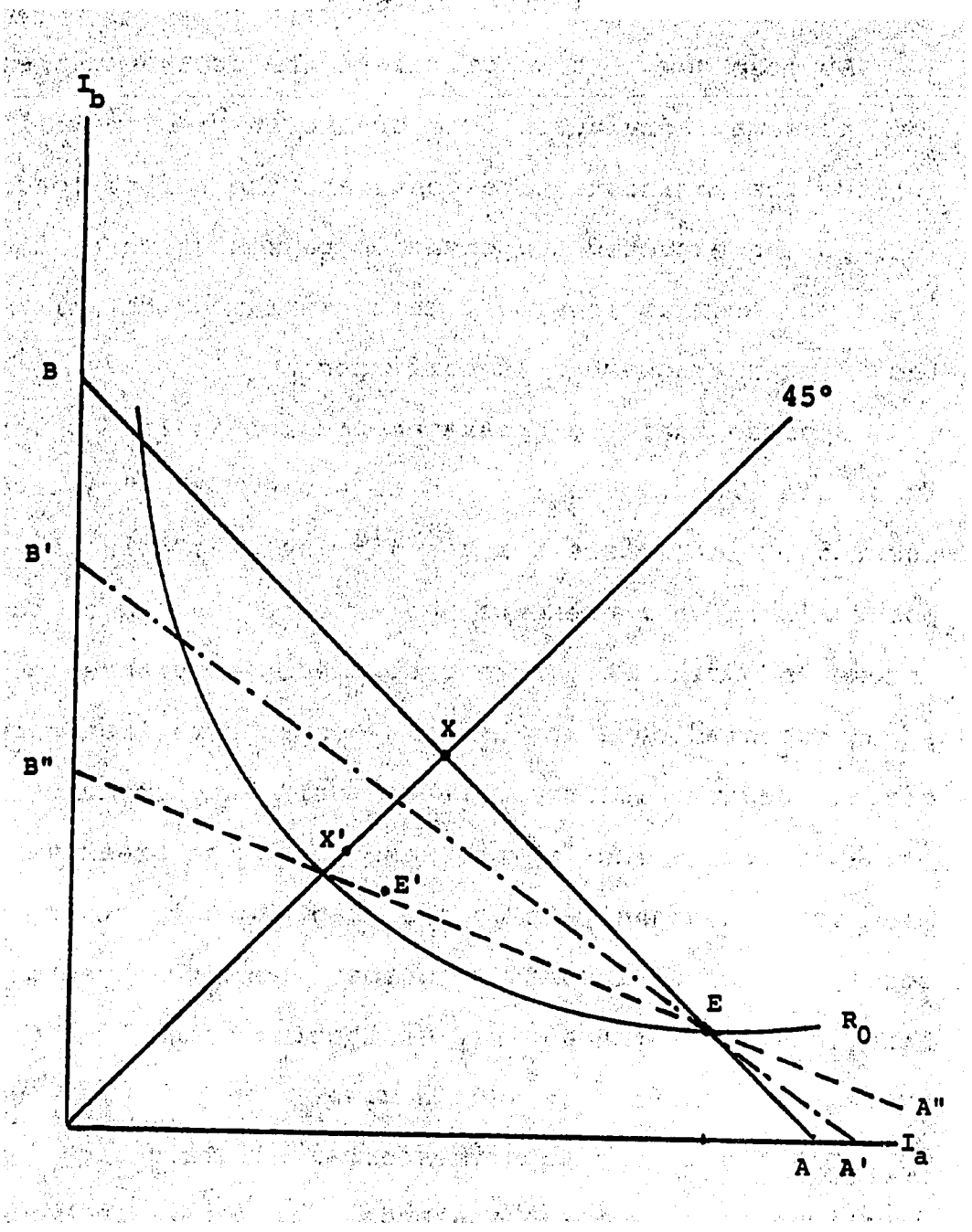
3. Do the benefits generated by crop credit insurance exceed the cost of providing the insurance?

We have spoken to this point of an actuarially fair insurance scheme. Administrative and safety loadings have been dropped from the premium. We will see below that if

we are going to insist on compulsory insurance (and most countries have), then the only way we can be sure of not causing as many production disincentives as incentives is to charge an actuarially fair premium. This means that administrative costs and safety reserves must be covered by governmental subsidies. The net social benefit of the increase in credit use caused by the introduction of insurance must cover the administrative costs and safety reserve costs of the insurance.

To illustrate this point, consider the example depicted in Figure V-1. Here we return to the static model, but extension to the dynamic case is straight forward. Suppose that point E represents the income endowment of the typical farmer who borrows funds from the agricultural bank. Point E' represents the income endowment of the same typical farmer who does not use official agricultural credit. Point E' lies on a higher indifference curve than point E, and therefore without insurance, the farmer will choose to self-finance production. If we introduce an actuarially fair insurance, the farmer will now choose to move along line AB from point E to reach point X on a still higher indifference curve. Suppose that the interest rate charged to the farmer covered the opportunity cost of capital and the administrative cost of providing the loan.

FIGURE V-1



Now the shift from point E' to point X represents an increase in the gross level of production.

Suppose now that we calculate the breakeven premium for the same individual. The breakeven premium will include the administrative costs and the safety loading as well as the expected compensation payment. Thus, the breakeven premium is simply that premium which will make the insurance scheme self-sufficient.

Suppose that the breakeven premium is led to an insurance line like A'B'. In this case, the breakeven insurance line intersects the 45° ray at a point above point X', which represents the expected income of the income endowment E'. Here crop credit insurance generates a net expected benefit which is due to both insurance and credit, because insurance is a contingent project.

Now let us look at the case where the breakeven premium is much higher. Line A"B" represents another, more costly breakeven insurance scheme. Here the insurance line intersects the 45° ray well below point X'. Costs exceed the benefits in such a case.

One might want to bring certain distributional considerations to bear in an instance like this. In Mexico, as was mentioned earlier, insured credit is offered to certain groups of farmers who are not financially viable as part

of the Mexican government's rural income distribution policy. This issue will be raised again below.

Once we have determined that crop credit insurance does generate a net social benefit, it is interesting to ask how this benefit is produced:

4. Does the benefit of crop credit insurance arise from the reduction in farm financial risk or from the increase in the supply of credit due to better control of defaults, or both?

If farmers are not very risk averse, as Roumasset claims, then the reduction in farm financial risk ought to produce few changes in the level of production. Even if this were the case, however, crop credit insurance could be an effective default management mechanism which will lead to lower interest rates or more lending or both A risk neutral farmer is just as likely to appreciate lower interest rates as a risk averse farmer. Thus, Roumasset could be correct in his empirical observation of farmer preferences but incorrect in his conclusion on crop credit insurance.

Finally, we have to consider the fact that crop credit insurance is being undertaken in a particular institutional framework and constellation of policies. We want to know, then:

5. What institutional framework and policy constellation is most favorable to crop credit insurance in terms of administrative costs, production incentives and social goals?

Of course, in a particular context there will be a host of specific empirical hypotheses relating to the conditions, crops, policy specifications and credit terms. The five questions described here will serve as the reference point for these specific hypotheses.

Problems of Generalization

Most of this thesis has been devoted to the analysis of crop credit insurance in a theoretical context. The reason for this theoretical focus is to avoid making premature judgements on crop credit insurance based on limited experience. As one of my colleagues in crop insurance research, Peter Hazell, likes to point out, the world we live in is only one of many theoretically possible worlds, and it is not necessarily the most interesting.

In this thesis, we have looked at the crop credit insurance programs in Mexico and Panama. In terms of the crop credit insurance programs which could exist in space and time and within a variety of institutional frameworks, this is a very limited and probably biased sample. Within

another five years of this writing, there may be three of four more crop credit insurance programs operating in Latin America. Even if one were to study all of the different kinds of crop insurance programs that have existed to date, the total number would hardly reach thirty -- the most minimal sample size for statistical analysis on just a few variables.

In Mexico today, we see widespread disappointment with the existing crop credit insurance program. Does this prove that crop credit insurance does not work? That it was always a bad program? That in a different institutional framework it might not work? That in a society with a different set of social goals it might not be satisfactory?

An empirical evaluation of the crop credit insurance program in Mexico and Panama will give us, not a final verdict on crop credit insurance, but information to help us arrive at a general conclusion.

In light of this, it is important to point out certain features of actual crop credit insurance programs in Mexico and Panama which would seem to detract from their overall efficacy. These "deficiencies" are all correctable, and need to be considered before any final negative judgement is made on either program.

A very significant problem in the Panamanian program is the lack of effective price stabilization. In such a

setting, crop credit insurance could well be magnifying the risk farmers face and the default problem of the Banco de Desarrollo Agropecuario, precisely because it is effective. If farmers respond to the production incentives provided by the insurance, they will increase production. At the time of harvest, they encounter the warehouses of Instituto de Mercadeo Agropecuario full and must sell their product to local grain wholesalers. Because of the very general price inelasticity of demand for foodstuffs, the price of agricultural products will drop more than yields have been increased, leaving farmers with smaller gross incomes (and higher production costs) than they would have had without insurance. Farmers then will have lower net incomes and more will be forced to choose between subsistence and loan repayments, leading to higher default rates.

Below, we will point out some additional complications which crop insurance may cause for long-run stabilization policy. However, no stabilization policy is as harmful as a poorly implemented stabilization policy.

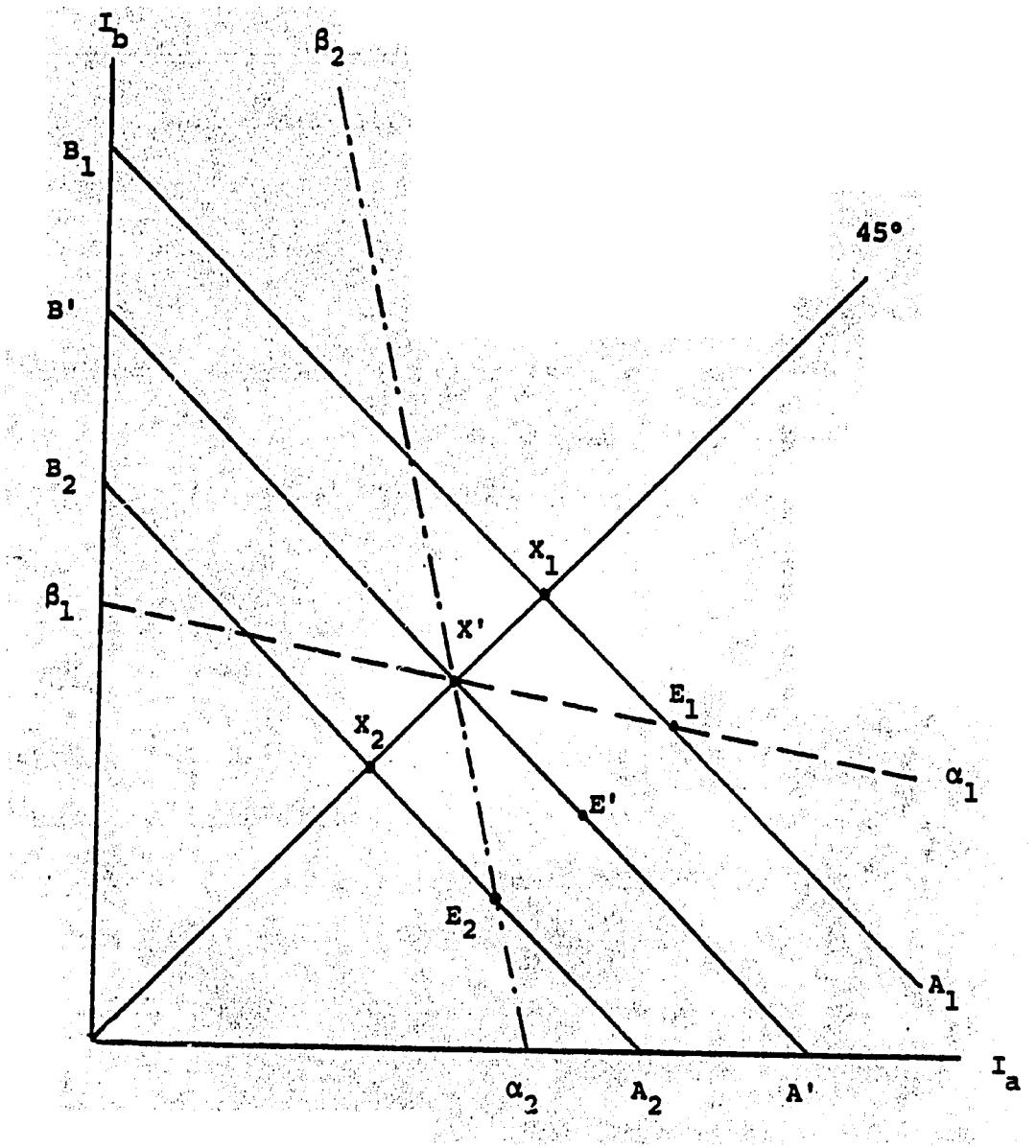
Another problem with both the Mexican and Panamanian programs is the widespread deviation of actual premium rates from those which are actuarially fair. In Mexico, all premium rates are subsidized -- a point we will return to in our discussion of crop insurance as a redistribution

strategy -- but the premiums are calculated for often heterogenous groups of farmers.

Each geographical region in Mexico where official credit is provided is part of an agroecological insurance zone. Within this zone, all borrowers cultivating the same crop with the same production technology pay the same premium. In Panama, all producers of the same crop using the same production technology in the same province pay the same premium rate. In both cases, the premium rates were designed to be actuarially fair for the group, apart from the subsidy in Mexico.

Figure V-2 illustrates the difficulties which can arise from this kind of premium rate setting procedure when the group of insured is not sufficiently homogeneous. Points E_1 and E_2 represent the income endowments for individuals 1 and 2 in an agroecological zone. If each individual were offered an actuarially fair insurance policy, they would purchase insurance to move from points E_1 and E_2 to points X_1 and X_2 respectively. However, if their experience is grouped to produce point E', the insurance scheme will then allow them to achieve point X'. If the insurance scheme is designed to produce an expected income corresponding to point X', then the true insurance line for individual 1 is $\alpha_1\beta_1$; the true insurance line for individual 2 is $\alpha_2\beta_2$.

FIGURE V-2



From Figure V-2, we see that individual 1 is not being offered an actuarially fair insurance policy, while individual 2 is being offered a superfair insurance policy. In this example, total income remains the same, $I(X_1) + I(X_2) = 2I(X')$, but income has been redistributed from individual 1 to individual 2. If points E_1 and E_2 represent the technically, economically and financially optimal production levels, then the provision of a superfair insurance policy to individual 2 is not an effective production incentive; no further gains in income can be achieved.

On the other hand, offering individual 1 an actuarially unfair insurance policy does constitute a production disincentive which could result in withdrawal from the credit program. If individual 1 remains in the credit program, assuming economic rationality and consciousness of the unfairness of the insurance policy, an attempt will be made to change the endowment from E_1 to E', since with insurance both have the same expected income. This might come about as a result of less intensive or timely cultivation practices which were subtle enough not to cause cancellation of the insurance policy. In either case, total income is likely to decrease.

We conclude, therefore, that if the principal goal of crop credit insurance is to increase total income by increasing the use of credit, then the best results will be attained by keeping the premium rate as close to actuarially fair as possible. Under these circumstances, we know that risk averse borrowers will be better off, the risk neutral borrower will be indifferent and any loss caused the risk-seeking borrower will be minimized. Where grouping must take place for practical reasons, retrospective reimbursement of low risk farmers should be considered after several years of participation.

We now turn to the question of subsidization of premium rates in Mexico. Premium subsidies have two justifications in Mexico. First, in some areas actuarially fair premium rates are so high (50-60%) that farmers cannot afford to pay them. The goal of the government of Mexico is to keep certain groups of marginal ejido farmers on the land and out of Mexico City. Insurance is merely an income transfer mechanism, and for that particular situation it is very likely to be as adequate as any other mechanism.

Most of the total premium rates calculated by ANAGSA run between 10-25% and they are not beyond the capacity of the farmer to pay. Nevertheless, they are all subsidized to some extent. Where difficulties arise in paying the premium, ANAGSA could follow ISA's lead and have the

premium payment incorporated into the loan. In this way, the premium will not become an out-of-pocket expense for farmers at a time when their cash reserves are very low. The money which is saved by eliminating the premium subsidies can be used to increase the level of lending. Since capital resources are scarce and premium subsidies produce no incentives to increase production, society as a whole would seem to be better off without premium subsidies. Income transfers can be achieved through other means that will not disguise the incentive structure of the credit or the insurance. Of course, this should be undertaken only after the problem of inappropriate group premium rates has been successfully resolved.

Finally, we come to the problem of the excessive supervisory burden placed on the insurance program. Crop credit insurance programs are designed to support programs of supervised agricultural credit. To a large extent, the loans are being supervised twice, even though the bank and the insurer have the same stated goal to increase the use and productivity of public investment in agriculture.

In both Mexico and Panama, a climate of rivalry and distrust has developed between the insurance programs and the agricultural banks. The banks claim, with some justification, that the insurance programs are slow, inefficient

and sometimes unfair in making compensation payments. The insurance programs are equally justified in criticizing the banks for trying to use insurance to pay bad loans arising from poor planning or moral hazard.

By creating two separate institutions with separate and sometimes competing goals, it was thought that a kind of healthy competition (checks and balances) would arise. To a large extent, this has occurred, but at the cost of maintaining two separate supervisory staffs.

The bank has a clear interest both in increasing the level of funds loaned and in controlling defaults. The problem of using insurance to cover up poor operating procedures is no different than other kinds of malfeasance, corruption and incompetence. To some extent, the existence of a separate and sometimes hostile entity (the insurance agency) may even lessen the bank's internal resolve to set its house in order, because it can sometimes export the consequences of its mistakes to the insurer.

The insurance program could be set up as a semi-autonomous branch of the agricultural bank. Supervision would then consist of oversight of field operations of the bank staff, not the maintenance of a duplicate staff. Such a branch would have direct access to bank records and would be able to exercise better control than the existing

autonomous agencies. Lastly, by this incorporation the concerns of the insurance program in terms of the selection of the portfolio of clients can influence the allocation of loan capital. If the bank attempts to exploit the insurance program by covering its bad debts with insurance compensation payments, it will be forced to deal directly with the budget deficits of the insurance program. It would seem, then, that such a consolidation would both reduce operating costs through the reduction of duplicatory staff, and it might encourage a more rational coordination of insurance and loan policies.

What about crop credit insurance for loans provided by private lenders? There is no reason why this program would have to end because of the consolidation of bank and insurer. In fact, this aspect of crop credit insurance gives little evidence of success; the anticipated rush by private lenders to provide insured loans to small farmers has not materialized. In Mexico in the last few years, there has been an increase in private lending to small farmers, with and without insurance. The government of Mexico requires private banks to dedicate a specified percentage of their portfolio to small farmer agriculture. This, not insurance, appears to be responsible for the increase in private lending. In Panama, there is almost

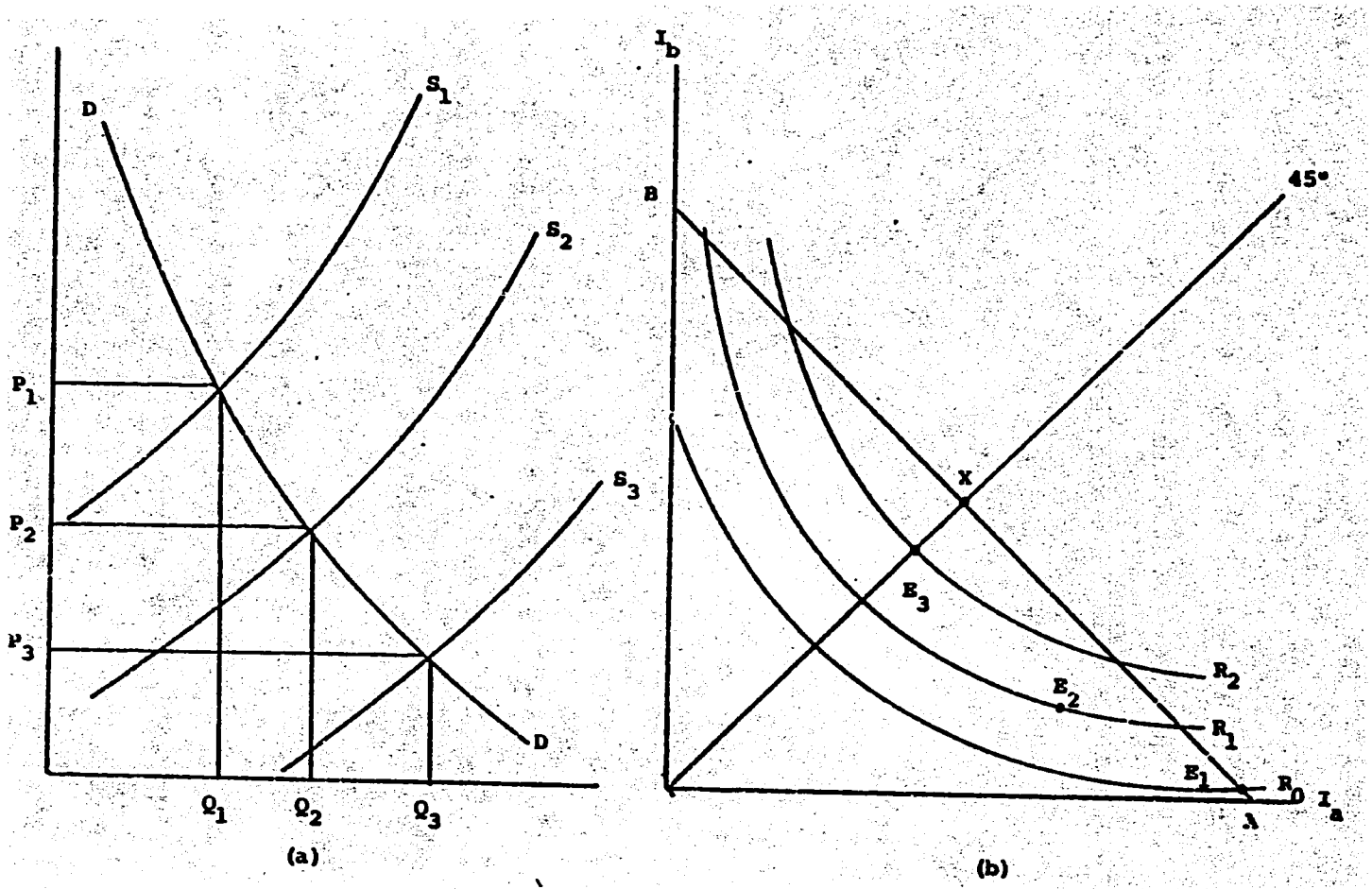
no private lending to small farm agriculture; what there is is almost entirely uninsured. At the present, any reasons we might offer for such a poor response to crop credit insurance by private lenders would be purely speculative.

Coordination of Price Stabilization and Crop Credit Insurance Programs

In Chapter 2, it was demonstrated that the introduction of crop credit insurance where prices were unstabilized and where a negative correlation existed between prices and yields would result in a final income stream more variable than before. All of the five Latin American nations (Mexico, Panama, Ecuador, Bolivia and Venezuela) which have or are contemplating the initiation of crop credit insurance programs are running substantial deficits in the production of basic grains. Of these, only Mexico has any significant experience as a basic grain exporter.

Technical change in agriculture often has a long run negative impact on producers. This has occurred in a number of countries where price stabilization was either not implemented or was ineffective. Consider the simple example depicted in Figure V-3a. Here we assume stable consumer preferences and a price (P) inelastic demand for food (Q). S_1 represents the supply function based on the

FIGURE V-3



technology available in Period 1. S_2 represents an intermediate case where technical change has taken place but is incomplete. Finally, S_3 represents the final and complete stage of technical change. We can see that gross farm revenue is declining as the supply curve is shifted to the right:

$$P_1Q_1 > P_2Q_2 > P_3Q_3 .$$

Suppose now that this process of technical change was being induced by the introduction of crop credit insurance. In this case, the scenario depicted in Figure V-3b is possible. Point E_1 represents the distribution of income across states of nature when a producer is on supply curve S_1. Point E_2 represents the intermediate case where technical change and income stabilization are at an intermediate stage. Point E_3 represents the typical producer's final gross income position, where production is described by the supply curve S_3 and stabilization is complete.

If the individual producer were risk averse, the movement from point E_1 to E_3 represents a real welfare gain. If, on the other hand, the farmer were risk neutral, points E_1 and X would lie on the same indifference curve and point E_3 would represent a real loss of welfare. We are making the assumption here that net income (the true decision variable) is in constant proportion to gross

income. Since the marginal product of labor increases as the level of capital increases, it is possible that disposable income will rise even as the gross income declines. Most Latin American nations subsidize the cost of farm inputs, like fertilizer, seeds and pesticides, as part of their technical change programs. Even so, the relative benefits to risk averse and risk neutral farmers will remain.

Figure V-3a is a fairly good representation of how price stabilization works in most developing countries. Price stabilization generally means a guarantee or floor on prices of specified products during the present production cycle and a softening of price fluctuations from period to period. Price stabilization does generally ignore long term trends. For example, in Figure V-3a, if prices were maintained at P_1, by the completion of the technical change process, there would be enormous surpluses $(Q_3 - Q_1)$, all of which the government would have to buy at P_1. The demands from the urban constituency to share in benefits of technical progress would be difficult to refuse in such a case.

Thus, given the very reasonable assumption of price inelasticity of demand for foodstuffs and a price stabilization policy oriented toward short term equilibrium,

it seems likely that crop credit insurance, to the extent that it is successful in inducing technical change in agricultural production, is more likely to benefit the risk averse farmer and the consumer than the risk neutral farmer. Analysis of this question deserves a much more complete treatment than we can give it here. In terms of the empirical research, this conclusion points out the need to study crop credit insurance in terms of a sectoral agricultural planning analysis process.

Models for Empirical Research

In late 1979, work began to develop an empirical model which could be employed in crop credit insurance research in Mexico and Panama. Hazell (1980a) proposed the original version of the model which was subsequently revised and tested with the help of the author (Hogan, 1980b). The most recent version of the empirical model can be characterized as a simple recourse, stochastic linear programming model with five discrete states of nature and five production technologies involving three different crops. The mathematical formulation of the latest version is the following:

(objective function)

$$\max U(I) = E(I_s) - R\sigma_I \qquad (1)$$

subject to:
(average income identity)

$$E(I_s) - \frac{1}{s} \sum_{s=1}^{s} I_s = 0 \tag{2}$$

(income identity in state of nature s)

$$I_s + \sum_{n=1}^{N} g_n x_n + iL + \rho v_s - \sum_{n=1}^{N} P_{ns} q_{ns} + \sum_{n=1}^{N} O_{ns} h_{ns}$$

$$- \sum_{n=1}^{N} (\xi_{ns} - \theta_n) u_n = 0 \; ; \; s = 1,\ldots,S \tag{3}$$

(debt repayment in state s)

$$I_s - L + b_s + v_s \geq M_s \; ; \; s = 1,\ldots,S \tag{4}$$

(average debt repayment)

$$E(I_s) - L - E(v_s) + E(b_s) \geq E(M_s) \tag{5}$$

(credit requirement)

$$\sum_{n=1}^{N} w_n x_n + \sum_{n=1}^{N} \theta_n u_n - L - Q \leq 0 \tag{6}$$

(own resources)

$$E(b_s) + Q \leq B \tag{7}$$

(credit limit from official bank)

$$\sum_{n=1}^{N} w_n x_n + \sum_{n=1}^{N} \theta_n u_n - L \geq 0 \tag{8}$$

(global insurance limit)

$$L - \sum_{n=1}^{N} u_n \geq 0 \tag{9}$$

(crop insurance limit)

$$L_n^* x_n - u_n \geq 0 \; ; \quad n = 1,\ldots,N \tag{10}$$

(technical constraints)

$$A\underline{x} \leq \underline{c} \tag{11}$$

(subsistence requirements)

$$e_{ns}x_n + h_{ns} - q_{ns} - \zeta_n I_s \geq C_n \tag{12}$$

$$s = 1,\ldots,S \; ; \quad n = 1,\ldots N$$

(anti-dumping constraint)

$$e_{ns}x_n - q_{ns} \leq 0 \; ; \; s = 1,\ldots,S \; ; \; n = 1,\ldots,N \tag{13}$$

(MOTAD rows)

$$I_s - E(I_s) + d_s \geq 0 \quad ; \quad s = 1,\ldots,S \tag{14}$$

(risk identity)

$$2 \sum_{s=1}^{S} d_s - \eta\sigma_I = 0 \qquad 15)$$

where

$U(\cdot)$ is the utility function;

$E(\cdot)$ is the expectation operator;

A is the matrix of technical coefficients;

$\underline{c}$ is a vector of resources availabilities;

$\underline{x}$ is a vector of crop production activities;

θ_n is the insurance premium rate for crop activity n;

u_n is the insurance coverage for crop activity n;

w_n is the financial requirement for crop activity n;

L is the amount of official credit loaned;

v_s is the amount of informal credit in state of nature s;

B is the amount of own financial resources;

Q is the amount of own resources invested in crop production, i.e., equity;

b_s is own resources used for consumption in state s;

R is the risk aversion coefficient;

σ_I is the standard deviation of income;

d_s is the deviation of actual from expected income in state of nature s;

N is the number of crops under cultivation;

S is the number of states of nature;

η is the Hazell transformation;

ζ_n is the physical increment to home consumption of crop n per dollar of income;

C_n is the subsistence consumption requirement in physical units;

e_{ns} is the physical output of crop n in state of nature s;

L_n^* is the maximum per hectare loan level for crop n;

I_s is the net income in state of nature s;

g_n is the production cost per hectare of crop n;

i is the official lending rate;

ρ is the informal interest rate;

P_{ns} is the selling price of crop n in state of nature s;

q_{ns} is the quantity of crop n purchased in state of nature s;

O_{ns} is the purchase price of crop n in state of nature s;

h_{ns} is the quantity of crop n purchased in state of nature s;

ξ_{ns} is the total insurance compensation for crop n in state of nature s;

M_s is the cash subsistence requirement in state of nature s.

The objective function (1) of the farm model is a mean-variance formulation. In the exercises performed with the model, the risk aversion parameter was varied parametrically from 0 (risk neutral) to 2.5. In general, there was no change in the basis after R = 1.0.

Income in each state of nature is defined in (3). Income consists of sales minus purchases minus official and recourse interest plus the net insurance compensation in that state of nature. Compensation was paid when yields fell below 80% of the average level. There were two compensation options employed. Option A paid 140% of the recommended credit limit per hectare (L_n^*). Option B paid the difference between the actual and expected revenues.

In each state of nature, the model was constrained to meet certain cash subsistence requirements, M_s. Disposable farm income had to cover loan repayment (L) and meet subsistence requirements. In any state of nature, recourse savings and recourse borrowing could be used to supplement disposable income (4), but overall income had to cover all loan repayment (5).

Financial requirements (6) were determined according to per hectare specifications for each crop. The model could either borrow (L) or self-finance (Q) to meet these financial requirements. Own resources could be used either to meet consumption needs or for investment (7). Official credit was restricted in its use to investment purposes (8).

Insurance coverage could not exceed the amount of total official credit (9) nor could coverage for any one

crop exceed the amount of official credit authorized for that crop (although some self-financing of the financial requirements was allowed)(10).

The model was constrained to provide a minimum diet C_n which was adjusted upward according to the level of income (ζ)(12). To prevent the dumping of production into subsistence consumption when the risk aversion parameter became very large, the model was constrained to sell no more physical units of production than it had produced.

Constraint sets (14) and (15) represent the MOTAD or mean absolute deviation approach to quadratic programming developed by Hazell (1971). The coefficient in (15) represents the appropriate transformation of the sum of absolute deviations in order to produce a standard deviation based on the F sampling distribution (σ_I).

The model just presented has two shortcomings. First the utility function represented in (1) does not possess the property of diminishing marginal utility of income. The mean-variance approach can lead to some bizarre behavior. For example, when this model was implemented using Panamanian data (Hogan, 1980b), it was discovered that as the risk aversion coefficient rose above 1.0, the model would purchase subsistence goods at a high price and sell

at a lower price in order to reduce positive deviations in expected income; (13) was imposed to prevent this. The model then proceeded to dump production into home consumption in order to reduce variance. While it is true that these deficiencies can be counteracted through additional restrictions, they point to basic flaws in the mean-variance model (see Roumasset, et al., Chp. 1).

My suggestion is that the mean-variance model be abandoned, allowing us to dispose of the MOTAD rows also. Instead of (1), the following objective function should be used:

$$\max U = \frac{1}{S} \sum_{s=1}^{S} \sum_{j=1}^{J} U_{js} I_{js} \qquad (1')$$

$$I_s - \sum_{j=1}^{J} I_{js} = 0 \; ; \quad s = 1, \ldots, S \qquad (2')$$

$$0 \leq I_{js} \leq \frac{1}{J} \cdot I_{max} \qquad (16)$$

where

$$U_{js} = \Psi^j \qquad \begin{cases} \text{if } \Psi = 1 \Rightarrow \text{risk neutral} \\ \text{if } \Psi < 1 \Rightarrow \text{risk averse} \end{cases}$$

$I_{max} = J \cdot I_{js}$, the income line is divided into J equal segments, each with a unique Ψ^j associated with it.

This form of a segmented utility function with diminishing utility can be ranged parametrically almost as easily as the mean-variance approach. The theoretical foundations of this model are clearly developed in this thesis and based upon the states of nature approach. The anomalous behavior observed with the mean-variance model will disappear.

The second shortcoming of the existing model is that it does not deal with the problem of default. Hazell (1981) in a separate research effort has advocated a chance-constrained formulation. Specifically, (5) would be reformulated as:

$$\Pr\left\{\frac{I_s - E(I_s)}{I} \geq \frac{K - E(I_s)}{I}\right\} \geq 1-\alpha \qquad (5')$$

where

α is the probability of noncompliance with the goal statement in the curly brackets and

$K = M_s + L$, the subsistence consumption requirement in state s and the official debt.

The certainty equivalent of (5') is derived by Hazell:

$$E(I) - K_\alpha \sigma_I \geq L + M_s \qquad (5a')$$

where

K_α is the standard normal deviate associated with α the probability level.

Chance constrained programming has been shown to be a deficient modelling and computational technique (Hogan, Morris and Thompson, 1981). Principal among these deficiencies is the inability to select the optimal level of α in a way that is not essentially arbitrary except by solving the conceptually and computationally difficult problem which the chance constrained approach was used to avoid. Even supposing that through some intuitional process the optimal level of α can be perceived, the resulting model is still seriously lacking in managerial relevance.

Consider the implication of (5a'): it says that assuming a particular probability distribution for income, we should select cropping activities which result in expected income covering loan repayment and subsistence needs at least $(1-\alpha)$ 100% of the time. This is to say that $\alpha \cdot 100\%$ of the time these needs do not have to be met, that is, we can default on the loan or starve.

In the chance constrained model, there is no penalty for not achieving the goal within the probability statement. We saw in Chapter 3 that defaults do, in fact,

affect the borrower, either through an increased interest rate or lower levels of lending. To ignore these costs would be to ignore one of the basic research hypotheses proposed earlier, that crop credit insurance may be effective in controlling defaults. To incorporate this feature in the present model, (5) can be rewritten as:

$$E(I) - L - E(v) + E(b) + D \geq M_s \qquad (5'')$$

$$D \leq L \qquad (5a'')$$

In addition, we must add $-(1 + \rho) D$ to the objective function, representing loan repayment with interest at the informal interest rate. A better treatment of the default issue would be possible with a multi-stage model, wherein the penalty of default would be both loan repayment with interest but also exclusion from the credit system until the loan is repayed.

The model in revised form can be tested within two or three years with data now being collected in Panama. The revised model should be tested with the data used to test the original model.

In Chapter 3 (eq. 32), we formulated a very simple model for an agricultural bank. An extension of this model to the case of a bank with several classes of loans is:

$$\max J = \sum_{n=1}^{N} [(\rho_n - i) - (1+i)d_n(L_n)]L_n \qquad (17)$$

$$\text{s.t.} \qquad L_n = D_n(k) \qquad n = 1,\ldots,N$$

The practical problem of working with both the insurance agency and the agricultural bank in either Mexico or Panama impedes the empirical implementation like that depicted in (17). As an alternative, a simplified approach can be pursued with only minimal cooperation required from the agricultural bank.

Here is presented a simple model with which to estimate the benefits of crop credit insurance. The net social benefit of insured credit can be estimated by taking into account the following components:

$$NSB_I = GSRR - (1+i)L - AC_L - D - S_L - AC_I - \Delta D_I - S_I + \Delta GSRR_I \qquad (18)$$

where

GSRR is the gross social rate of return on credit;

i is the opportunity cost of capital;

L is the loan unit, i.e., $L = 1$;

AC_L is the rate of administrative cost of the loan;

S_L is the rate of subsidy in the interest rate, i.e., $S_L = i - K$, where K is the interest rate paid by the borrower;

D is the rate of default without insurance;

AC_I is the rate of administrative cost of the insurance;

S_I is the rate of subsidy in the premium rate;

ΔD_I is the change in the default rate due to insurance;

$\Delta GSRR_I$ is the change in the gross social rate of return due to insurance.

The gross social rate of return requires a more precise definition. Assume that for some crop for which loan funds are being made available, the production function is:

$$W = W(Q,L) \ , \tag{19}$$

where

Q represents self-financed inputs;

L represents debt-financed inputs.

The gross social rate of return for an additional dollar of loan funds is:

$$GSRR = P \cdot \partial W(Q,L)/\partial L \ , \tag{20}$$

where

P is the price of the agricultural product and

$\partial W/\partial L$ is the marginal physical product of the debt-financed input.

If we introduce crop credit insurance, (19) becomes:

$$GSRR_I = P \cdot \partial W(Q,L,I)/\partial L \tag{21}$$

where

$GSRR_I$ is the gross social rate of return when credit is insured, i.e., with the production function $W = W(Q,L,I)$, I being the insurance.

Thus, the change in the gross social rate of return due to insurance is merely (20) subtracted from (19):

$$\Delta GSRR_I = GSRR_I - GSRR = P(\partial W(Q,L,I)/\partial L) - \partial W(Q,L)/\partial L). \tag{22}$$

In the absence of crop insurance, the net social benefit rate for agricultural credit is:

$$NSB = GSRR - (1+i)L - AC_L - S_L - D\ . \tag{23}$$

Therefore, the rate of benefit due to the introduction of crop credit insurance can be measured by subtracting (23) from (18):

$$V = NSB_I - NSB = \Delta GSRR_I + \Delta D_I - AC_I - S_I\ . \tag{24}$$

Thus, the benefit for crop credit insurance consists of the change in the gross rate of social output resulting from the introduction of insurance, the change in the default rate of the credit program and the rate of administrative cost to administer the insurance scheme. If there is a premium subsidy, it will increase the gross social rate of return; therefore, we subtract off the premium subsidy, since it is a transfer payment.

The rate of net social benefit due to crop credit insurance will provide a summary statistic with which to calculate the total value of the crop credit insurance program. The total coverage of a crop credit insurance program is approximately equal to the value of the loan portfolio of the credit program. Thus, the total benefit of insurance is:

$$TB = V \cdot C \tag{25}$$

where

TB is total benefit,

C is total coverage, and

V is the net social benefit rate of the insurance.

The empirical estimation of (24) can proceed in the following manner:

1. From the Banco Nacional de Credito Rural in Mexico and the Banco de Desarrollo Agropecuario in Panama, information of the administrative costs of credit (AC_L), the default rate on insured credit ($D+\Delta D_I$) and the interest rate subsidy (S_L) will be obtained.
2. From the Aseguradora Nacional Agricola y Ganadera, S.A., in Mexico and the Instituto de Seguro Agropecuario in Panama, information on the administrative costs of crop insurance (AC_I) and the premium subsidy rate (S_I) can be obtained.
3. In Mexico, from the SAM group (Sistema Alimentario Mexicano), information of the social discount rate (i), the gross social rate of return on agricultural credit with and without insurance (GSRR and $GSRR_I$), and the default rate on uninsured agricultural credit (D) can be obtained. $GSRR_I$ and D will be estimated using the redesigned agricultural planning model (CHAC), which has been recently utilized to test the benefits of the new insurance rates for the SAM pilot regions (Hazell, 1981). These exercises can be easily repeated with minor modifications to address the issue raised in this section. In Panama, the farm model mentioned above will be used to produce the information on the uninsured default rate and the gross social rate of return in the same way the CHAC model will be employed.

The results of these analyses must be interpreted with some caution. We will not have attempted a complete model of the agricultural credit system, and therefore the results will be conditioned by the state of the system at the point of measurement. In particular, we should not be surprised to find a negative social rate of return in Panama, given the ineffectiveness of the price stabilization program. In Mexico, so many policies have changed simultaneously under the Mexican Food System (SAM), that it will probably not be possible to isolate the effects of insurance from the effects of the new input subsidies.

A preferred approach to this issue is to develop a mathematical model of the entire agricultural credit system. At present, the crop credit insurance research project has neither the resources nor the desire to undertake such an effort. It would seem, then, that decisions will have to be based on a piecemeal analysis which will not fully answer all of the relevant questions.

Conclusions

In this chapter, we have discussed the principal empirical research issues which should be addressed in the forthcoming field research in Mexico, Panama, Ecuador and Bolivia. We have also examined the difficulties in

drawing general conclusions from the rather limited set of experiences available for empirical investigation. Lastly, the empirical farm model to be used in investigating the impact of crop credit insurance on the willingness to borrow was reviewed and modifications were suggested. Also, a simple model for estimating the effect of crop credit insurance on the agricultural bank's lending practices was proposed.

CHAPTER 6

SUMMARY AND CONCLUSIONS

In Chapter 1, it was explained that crop credit insurance arose in response to difficulties presented by small farmers in agricultural credit programs in developing countries. Crop credit insurance was seen as a method to control loan defaults and the resulting decapitalization of agricultural credit programs. It was also hoped that crop credit insurance would reduce small farmer reluctance to participate in agricultural credit programs.

We also reviewed the progress which has been made to date by the Crop Credit Insurance Research Project of the Interamerican Institute of Agricultural Sciences. The purpose of this thesis was explained to be the development of a conceptual foundation for the farm level and institutional research which is now underway in Panama, Ecuador and Bolivia.

In Chapter 2, the importance of determining the correlation between crop yields and crop prices was explained. Where yields and prices are negatively correlated, piecemeal price stabilization or crop insurance may actually make farm gross revenue more variable than before.

A mathematical model of farm income was presented, and the importance of the debt/equity ratio was explored. It was shown that as the debt/equity ratio increases, the farmer's net income will become increasingly risky. It was reasoned that very poor farmers, farmers with little equity, are often asked to accept very high debt/equity ratios as a result of participation in agricultural credit programs. This, rather than a "culture of poverty" mentality, explains small farmer reluctance to participate.

We, then, distinguish crop credit insurance from other types of crop insurance. Crop credit insurance is used within the framework of a supervised credit program and coverage limits are linked to the quantity of the loan.

A mathematical model of crop insurance was adapted from the work of Issac Ehrlich and Gary Becker (1972). This model was used in the static context to demonstrate the conditions under which the risk averse farmer would choose crop credit insurance. The effects of deductibles and coinsurance on farmer decision making were explored. It was demonstrated that the non-risk averse decision makers might not be injured by compulsory insurance. The risk neutral decision maker was shown to be indifferent

to insurance, while the risk seeking farmer would suffer a welfare loss but only if reasonable gambing opportunities do not exist in the society.

The effect of crop credit insurance on the adoption of new and riskier technology was explored. It was shown that conditions can exist in which risk aversion alone will inhibit the adoption of new and profitable technology because the technical change involved a major increase in indebtedness. An actuarially fair insurance scheme was shown to be effective in overcoming the risk magnification effects of greater indebtedness.

Finally, in the static context crop credit insurance was compared to two alternative risk management strategies - share tenancy and crop diversification. We saw that in some instances crop diversification might make crop insurance superfluous, but that these cases were likely to be rare. Where crop diversification was undertaken to enhance resource allocation, it was remarked that an insurance policy could be devised to cover the diversified cropping pattern.

Share tenancy was examined as an alternative to crop insurance. Except in the extraordinary case where share tenancy makes possible a change in the scale of production which brings about a reduction in gross revenue variability, share tenancy cannot offer the same degree

of risk reduction obtainable through crop credit insurance. It is, however, an empirical question whether a particular crop credit insurance scheme with deductibles, coinsurance, exclusions and administrative overhead is preferable to existing share tenant contracts.

In Chapter 3, the static insurance model was adapted to a dynamic (two period) setting. It was shown assuming the diminishing marginal utility model of risk aversion that the decisions to allocate income across time and states of nature are independent. Therefore, intertemporal utility optimization will determine the level of expected income in each time period, and insurance or other risk management devices will be employed to smooth out the income stream across states of nature. In this context, crop insurance was shown to be an effective strategy for risk managment, in comparison to forced savings and forecasting.

Forced savings was demonstrated ineffective in reducing the riskiness of the income stream, unless a subsistence floor model of risk aversion were adopted. Forecasting can, in conjunction with a perfect bond market, reduce the riskiness of the net income stream. However, when costless forecasting was compared to costless crop insurance, the crop insurance was shown to be superior.

The dynamic model of crop insurance was adapted to investigate the process of technical change. Again, it was shown that the risk averse farmer might choose traditional over modern technology in spite of the economic superiority of the latter. Again, the increased indebtedness required to adopt the new technology was responsible for the choice not to modernize. An actuarially fair insurance scheme would make it possible to overcome these risk considerations and adopt the new technology.

Finally, we reviewed a model of an agricultural bank, and it was shown that loan defaults will either increase the interest rate charged borrowers or decapitalize tne bank. We discussed how crop credit insurance might help to reduce defaults and to increase the optimal level of lending. It was demonstrated that all kinds of borrowing farmers (risk averse, risk neutral and risk seeking) might benefit from a compulsory crop credit insurance program, if the insurance is effective in improving the supply or the price of credit.

In Chapter 4, we began with a simple illustration of the theory of the Second Best which requires that economic policy analysis take account of institutional factors. A general model of the agricultural credit system in a developing country was presented. This model

illustrated how the price stabilization, food importation, agricultural credit, insurance and technical change policies influence farmer decision making.

The credit system model was then applied in detail to the case of Mexico. The implications of this analysis were that the Mexican insurer (ANAGSA) had little power to influence its own institutional or financial viability. Criticisms of ANAGSA being too expensive have ignored the institutional context in which the insurer must operate and the costs which the decisions of other official institutions have imposed on it.

Next, we analyzed the crop credit insurance program in Panama (ISA). Here again, we found the insurer very much circumscribed in its ability to guarantee its own financial viability. The relationship between the agricultural bank and the insurer is, as in Mexico, strained. The insurance scheme, unlike Mexico, receives a very modest subsidy from the central government and relies on actuarially unfair premiums on mechanized rice to cover administrative costs and compensation payments for crops with high loss ratios.

A major problem in the Panamanian agricultural credit system springs from the ineffectiveness of the price stabilization program. The stabilization agency (IMA) is frequently unable to accept farmer grain shipments.

Farmers are then left with no recourse but to sell in glutted local markets, often at prices below the price guarantee.

In Chapter 5, the five principal research issues for crop credit insurance were presented:

1. Does crop credit insurance increase the use of agricultural credit?
2. Does the increased use of agricultural credit generate a positive net social benefit?
3. Do the benefits generated by crop credit insurance exceed the cost of providing the insurance?
4. Does the benefit of crop credit insurance arise from the reduction in farm financial risk or from the increase in the supply of credit due to better control of defaults, or both?
5. What institutional framework and policy constellation is most favorable to crop credit insurance in terms of administrative costs, production incentives and social goals.

Before presenting the empirical models for data analysis, several problems with the existing programs in Mexico and Panama were discussed. The major problem in Panama is the lack of effective price stabilization. In both Mexico and Panama, the practice of not offering

actuarially fair premiums was criticized because of the production disincentives created thereby. Also, the practice of premium rate subsidies in Mexico was examined and found to be often unnecessary. Lastly, it was pointed out that overall administrative costs of the agricultural credit system could be substantially reduced by incorporating the insurance program into the agricultural bank. This would eliminate much of the duplicatory supervisory effort and would force the agricultural bank to take into account insurance considerations in the selection of its portfolio of loans.

We then reviewed the empirical farm model which has been prepared to analyze the microeconomic data from Panama. Some modifications to the farm model were offered.

Given the difficulty and expense in performing a full-scale systems analysis of the agricultural credit system in either Mexico or Panama, a simplified procedure for estimating the net social benefit of crop credit insurance was proposed. This procedure can be applied in both Mexico and Panama.

The general conclusion of this thesis is that crop credit insurance is an agricultural development strategy worthy of further study. There is no _a priori_ reason to believe that crop credit insurance is unnecessary, exces-

sively costly or unproductive. It is clear that there are some circumstances in which crop credit insurance may not be indicated; it is not a universal palliative for all the problems of supervised credit. Furthermore, it is possible that crop credit insurance may not be generally effective in the absence of price stabilization. All of these considerations argue for a systems approach to agricultural credit research, rather than the actual piecemeal approach.

BEST AVAILABLE DOCUMENT

Annex-I-1

ASEGURADORA NACIONAL AGRICOLA Y GANADERA, S.A.

PROGRAMA DE ASEGURAMIENTO AGRICOLA

HOJA 1

I GENERALIDADES

II AREAS DE INFLUENCIA

III - SEMILLAS Y FECHAS DE SIEMBRA

ASEGURADORA NACIONAL AGRICOLA Y GANADERA, S.A.

PROGRAMA DE ASEGURAMIENTO AGRICOLA

HOJA 2

TRATAMIENTO FERTILIZANTE 95-90-0 C-CH: 130 KG. UREA 46% .- SE CONSIDERO REGION INSECTICIDA PARA LAS SIGUIENTES PLAGAS: PICUDO, G.SOLDADO, MEXILOR, HELIOTERO. LANTE, P. METILICO, P. ETILICO, TOXAFENO, CURACION NUVACRON.
SE CONSIDERA APLICAR HERBICIDA PREMERGENTE TREFLAN 3.25 KG/HA.

IV - LABORES

CLAVE	NOMBRE	PRECIO			
320	[illegible] SIEMBRA	25.00	01		
420	[illegible]	500.00	02	PBF	
830	[illegible]	1000.00	02	LBC	
850	[illegible]	200.00	01	PCA	
100	SEMILLA	375.00	01		
110	SIEMBRA	225.00	01	PCA	
200	FERTILIZANTES	1135.00	01		
210	APLIC FERTILIZ.	160.00	02		
280	TRANSP. FERT.	70.00	01		
400	HERBAS	200.00	01	HBL	
310	[illegible]	250.00	01	HBL	
360	[illegible]	800.00	04	CLT	
360	[illegible]	400.00	01	HBL	
540	INSECTICIDAS	425.00	00		
545	APLIC INSECTICIDA	180.00	01	PBD	
500	INSECTICIDAS	2500.00	00		
505	APLIC INSECTIC	2635.00	10	AAM	
550	APLIC INSECTICIDA	25.00	00		
740	SERV. INTEGRAL	140.00	00		
605	COSECHA	225.00	00		
	TOTAL	14240.00			

BEST AVAILABLE DOCUMENT

Annex-I-2

ASEGURADORA NACIONAL AGRICOLA Y GANADERA, S.A.

DEPTO. DE OPERACIONES AGRICOLAS SECCION DE PROGRAMACION

PROGRAMA DE ASEGURAMIENTO AGRICOLA

HOJA 1

I GENERALIDADES

191	1812		TCSEP	0	TEMPORAL	SEB FERT	300	
C035C0C	1016.00	C010001	290003C		1450			

II - AREAS DE INFLUENCIA

						TOTAL					
67	C1	95.00	0.00	0.00	0.00	95.00	7.45	10.15	22.60	11.70	13.90
TOTALES		95.00	0.00	0.00	0.00	95.00	7.45	10.15	22.60	11.70	13.90

III - SEMILLAS Y FECHAS DE SIEMBRA

CLAVE	VARIEDAD									
4004-563		15C	12	100.0015	C575	1006	7912	1079	2711	79
4014-567		15C	12	100.0015	0575	1006	7912	1079	2711	79
4504-568		15C	12	100.0015	C575	1006	7912	1079	2711	79
4914-569		15C	12	100.0015	C579	1006	7912	1079	2711	79
194	CEBOLLA	15C	12	100.0015	C579	1006	7912	1079	2711	79

ASEGURADORA NACIONAL AGRICOLA Y GANADERA, S.A.

PROGRAMA DE ASEGURAMIENTO AGRICOLA

HOJA 3

PROGRAMA ESPECIAL PARA EL I.N.I. (INSTITUTO NACIONAL INDIGENISTA) EN LA ZONA DE MICHUCALCO SE PROYECTA ASEGURAR LA CUOTA DEL PRESTAMO DEL BANCO'

IV - LABORES

CLAVE	NOMBRE	PRECIO			
01C	LIMPIA TEMPRAL	200.00	01	HAL	
10C	SEMILLA	10.00	01	HAL	
11C	SIEMBRA	300.00	01	HAL	
300	FERTIFERE	15.00	01	HAL	
506	INSECTICIDAS	96.00	01	HAL	
565	AFLIC INSECTIC	96.00	01	HAL	
	TOTAL	1016.00			

OBSERVACIONES GENERALES

INSECTICIDA: DIPTEREX AL 2.5% 12 KG. POR HA.

REPRESENTANTE BANRURAL — GANADERO — ANAGEA

BEST AVAILABLE DOCUMENT

Annex-I-3

ASEGURADORA NACIONAL AGRICOLA Y GANADERA, S.A.

DEPTO. DE OPERACION AGRICOLA DIRECCION DE PROGRAMACION

PROGRAMA DE ASEGURAMIENTO AGRICOLA

HOJA 1

I GENERALIDADES

CULTIVO					TIPO				

II AREAS DE INFLUENCIA

						TOTAL				
TOTALES										

III SEMILLAS Y FECHAS DE SIEMBRA

CLAVE	VARIEDAD										

ASEGURADORA NACIONAL AGRICOLA Y GANADERA, S.A.

PROGRAMA DE ASEGURAMIENTO AGRICOLA

HOJA 2

PARA LAS ZSD 14, 15-16, 16-A, 16-B-25 y 25-A LAS FECHAS LIMITES DE SIEMBRA SON DEL 10-08-79 AL 20-08-79.
PARA LAS ZSD 21 SAN FERNANDO Y TESMACINTA Y ZSD 63-A CHICOASEN - - -
ZSD. 20-A CHIAPA DE CORZO (MIRG). TUXTLA GUTIERREZ. - - - - - - - - - - -
ZSD. 20-A ACALA. CHIAPILLA. CHIAPA DE CORZO (MIRG) LAS FECHAS LIMITES SON DEL 10-08-79 AL 20-06-79.
ZS.D. 20-A TOTOLAPA. ZSD. 10 MITO. 10 EL ZARZAL LAS FECHAS LIMITES - DE SIEMBRA SON DEL 20-05-79 AL 10-06-79.
ZSD. 24 VILLAFLORES, ANGEL ALBINO CORZO LAS FECHAS LIMITES DE SIEMBRA SON DEL 15-05-79 AL 15-06-79.
ZSD. 20 OCOZOCOAUTLA Y BERRIOZABAL LAS FECHAS LIMITES SON DEL. - - - 15-06-79 AL 20-07-79.

IV LABORES

CLAVE	NOMBRE	PRECIO			

FERTILIZANTE: 100 KG. 18-46-0 140 KG. UREA 46%
INSECTICIDA: 80 KG. DE DIPTEREX

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