AN ECONOMIC ANALYSIS OF FARM REVENUE INSURANCE

By

David Dale Trechter

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ABSTRACT

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In the 1981 Farm Bill, Congress included a provision calling for a study of the feasibility of replacing current farm income support programs with a farm revenue insurance program. Purchase of a revenue insurance policy would guarantee a farmer some minimum level of gross receipts from his farm operation. The insurable level would be determined from a farmer's average returns over a base period and would adjust over time to reflect changing market conditions and inflation. The program would not guarantee a level of net income nor would the protection cover off-farm earnings.

Expected Value-Variance models of revenue insurance demand and supply were developed. These models predict that as buyers become more risk averse, face a higher premium, become less wealthy or, in general, as the environment becomes more uncertain, the level of insurance coverage sought will increase. A supply model is derived by aggregating across buyers. A seller will offer higher levels of coverage if he knows buyers have become more risk averse, if his own risk aversion decreases or if there is a decline in the degree to which his clients' outcomes are correlated.

A computer program was developed to examine the cost of and farmer attitudes toward a revenue insurance program. Twenty farmers were questioned about revenue insurance. Many farmers expressed disinterest and skepticism about revenue insurance. Many felt the

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insurance premium would be expensive, record keeping burdonsome and cheating rampant. Despite these initial reactions most farmers indicated they would willingly pay a premium that would more than cover the estimated indemnity costs of the program. Indemnities proved to be much lower than anticipated. One explanation is the expected negative correlation between prices and quantities. Another possibility is that because tax data were used, stability of farm revenues was overstated. A revenue insurance seems capable of drawing participants from farms of all sizes. Younger farmers, in particular, seemed attracted to it.

Since cost and level of coverage are dependent upon the management decisions of the individuals, revenue insurance could help coordinate the food system by improving transmission of market signals yet protect individual farms from unstable markets.

This dissertation is dedicated to my mother, Mary Trechter who suffered through the birth of me, and to my wife, Kristen Allen, who suffered through the birth of this dissertation.

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Chapter 1:

Introduction

In the 1981 Farm Bill, Congress included a provision calling upon the United State Department of Agriculture to study the concept of farm revenue insurance as an alternative or supplement to the existing set of agricultural programs. The specific terms of the revenue insurance program have not yet been determined but its intent is clear. A revenue insurance policy seeks to offer the American farmer some protection from both economic and environmental events which adversely affect his earning potential. This dissertation provides an economic analysis of revenue insurance. Of particular concern is the distribution and level of the program's costs.

Public Policy in Agriculture and the Rationale for Revenue Insurance

A useful way of thinking about agricultural policy is as a societal decision regarding the allocation of risks associated with agriculture. A policy maker has a spectrum of policy choices regarding the allocation of risk bearing responsibilities. The options range from policies allocating all risk bearing costs to the farmer to options which allocate these costs to society as a whole.[1]

Risk, in this study, is defined as any uncertain outcome which affects the well-being of a decision maker.[2] Risks may result from events in the physical environment (weather, pests or disease) or market factors (institutional changes, political events, inflation, changes in consumer demand patterns, etc.). The characteristics of

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some types of hazards allow risk bearing responsibilities to be shifted between individuals. For example, hail insurance is purchased by many farmers. This allows them to shift part of the risk bearing responsibilities for this environmental threat to the insurance company. This option is available to farmers because, in insurance parlance, the risk of hail damage can be successfully "pooled". Hence, they are "insurable". To be insurable implies that individuals in the pool face risks that are not highly correlated in a positive way, there are sufficient numbers of people in the pool to calculate accurately the probability of loss in a given period and losses are accidental and measurable.[3] Many risks faced by agricultural producers do not conform to all these prerequisites. "Indeed, the absence of adequate insurance markets has provided a significant part of the rationale for government intervention, and particularly for government price stabilization programs" in agriculture.[4]

Revenue Insurance within this Conceptual Framework

Given this conceptual framework for agricultural policy, how can the revenue insurance proposal be classified? With respect to the allocation of risk bearing, revenue insurance may at first appear to be a shift to greater reliance on private risk bearing. The validity of this impression depends entirely upon the form in which the program is implemented. If revenue insurance follows the pattern of Federal All-Risk Crop Insurance, where the administrative costs of the program are borne entirely by the government and all policies sold by private insurance companies are re-insured with the federal government, the shift of responsibilities to the private sector may not be substantial. If, on the other hand, options markets are instituted by the government allo

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allowing insurance companies to shift some of the market risks and no subsidies or government re-insurance are offered, a significant shift of risk bearing from the public to the private sector would be observed. How the burden of risk would be allocated within the private sector (between insurance companies, options markets and farmers) under this scenario is unclear.

The Case for Revenue Insurance

The current administration is interested in revenue insurance because it believes that wherever possible private institutions should replace governmental ones. According to this view, the function of the government, with respect to revenue insurance, is to provide the institutional setting within which the private sector can successfully pool the risks associated with agriculture. A multitude of private institutions for transferring risk from one party to another already exist and many feel these institutions are better able to handle this function than are bureaucracies. Furthermore, many believe that government policies, as now constructed, disrupt agricultural markets. Decisions about the form and substance of agricultural policies are the subject of intense speculation on the part of market participants. Numerous instances of markets reacting to expected or actual changes in policy could be cited. This is seen as an unfortunate side effect of the current programs.

Related to these philosophical concerns are several economic reasons for looking at the revenue insurance option. One is the embarrassingly large stockpiles of grain and dairy products currently held by the government. These stocks are believed to have an adverse impact on agricultural markets because participants do not know when

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they might be used to influence market conditions. Revenue insurance would remove the government as a major actor in the commodity buying and storage business in the sense that this mechanism would no longer be used for farm income protection. In addition, the rapidly escalating cost of farm programs provides an impetus for examining the revenue insurance proposal. Proponents of this policy believe it will reduce government expenditures on behalf of agriculture. The likelihood of this being the case depends upon the form such a program takes.

At a microeconomic level, revenue insurance is seen as a way of improving the planning efforts of farmers. By helping stabilize farm revenue, revenue insurance would reduce financial uncertainties. Assurance of a minimum level of revenue would help the farmer plan investment decisions, particularly in longer lived investments such as plant and equipment. Improved planning capacity could have important consequences for the coordination and performance of the food system. For instance, one macroeconomic manifestation of farm level uncertainties is the phenomenon of cycles in the price of agricultural commodities. Explanations of cycles are many (inaccurately framed price expectations, efforts by the farmer to minimize tax payments by investing in fixed assets in good years, an inelastic demand curve, etc.). Revenue insurance may not directly affect the underlying causes of cycles, but would reduce economic dislocations caused by them by stabilizing gross receipts earned by the farm.

Finally, revenue insurance would allow the insurer to profit from inter-farm variation of revenue experience. For example, the preceding paragraph raised the issue of cycles in agricultural markets.

From an insurer's point of view, there are two aspects about cycles that are interesting. First, it is unlikely that all cycles will be at the same point in their oscillations in the same period. This means that by insuring a cross section of farm types, the insurance company can use these cycles to its advantage in the sense of reducing variations of indemnity outlays. Second, even within a given type of output, there will be variations about the mean. Tracking the hog cycle entails the plotting of average prices received on a given day over a period of time. Within this average figure are individuals who experience prices on either side of the mean. Some of these individuals will receive high prices and no indemnity. In short, it is not expected that the revenue experience of farms producing a given type of output to be perfectly correlated. Furthermore, when considered across different types of output, the likelihood of positive correlation is further reduced.

The Need for an Analysis of Revenue Insurance

There are at least three significant differences between use of revenue insurance as the principal policy tool and current policy efforts. First, revenue insurance seeks to stabilize revenue rather than prices or quantities. Virtually all previous policy efforts to protect farm income have tried to manage the quantity of agricultural products produced or marketed (ie. land set asides, stockpiles, marketing orders, etc), the quantity of products demanded (P.L. 480, food stamps, etc.) or the price received by the farmer (ie. price supports, deficiency payments and non-recourse loans). Both prices and quantities are instrumental variables on the variable in which the farmer is ultimately interested, income or profits. Revenue insurance is focused more directly on a variable of concern than are current programs. As a result, revenue insurance represents a major change in the direction of policy.

Revenue insurance may also shift the incidence of risk bearing. The degree to which revenue insurance changes the existing distribution of risk bearing responsibilities depends largely upon the specific provisions of the policy. Finally, regardless of the final incidence of risk bearing, a revenue insurance program would shift implementation from public to private institutions.

Any time significant policy changes are contemplated, the degree of uncertainty in the food system is increased. There is uncertainty about the cost of the program, how it might be implemented, the distribution of costs and benefits, participant responses to their altered choice set and so on.

Organization of the Dissertation

The next chapter provides an historical perspective of the experience several countries, including the U.S., have had with agricultural insurance. This chapter also provides a more detailed description of the specific provisions assumed for the revenue insurance program. Chapter 3 reviews the insurance literature in the disciplines of economics and psychology. This review will include both theoretical models and empirical investigations of insurance markets.

In chapters 4 and 5 theoretical models of a revenue insurance market are developed. Chapter 4 derives a microeconomic model of revenue insurance demand. The principal reason for building the microeconomic model is to understand likely farmer responses to

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revenue insurance and focus attention on factors that may determine the degree of success a revenue insurance program will have. Chapter 5 tackles the difficult task of building an aggregate model from farm level results. The aggregate model is needed to gain insights into some of the program design questions which will have to be answered by a policy maker considering a revenue insurance program. These models also provide equations for participation rates and insurance costs as a function of the buyers probability density function over revenue, and the risk aversion characteristics of the participants.

Chapter 6 reports the results of empirical work examining revenue insurance demand. Conclusions about revenue insurance based on the empirical evidence are offered.

The seventh chapter examines in a more general way the effect of a revenue insurance program on some of the problems facing U.S. agriculture in the 1980s. Based upon the results obtained in the earlier chapters, the impact of a revenue insurance program on agricultural production, the structure of the farming sector and farm incomes will be examined. The eighth chapter will summarize the conclusions reached and indicate directions for future research.

1. I am grateful to Dr. Kenneth Clayton U.S.D.A. for framing the issue in this manner for me.

2. Lindon Robison and Bev Fleisher, 1984, p. 10.

3. Green, Mark R., 1977, p. 49.

4. Newbery, David M.G. and Joseph E. Stiglitz, 1981, p. 8.

Chapter 2

A Short History of Agricultural Insurance: Lessons for the Design of a Revenue Insurance Program

The motivation for a review of agricultural insurance is to obtain a broader perspective from which to analyze revenue insurance. Such a review can point out flaws in the design of earlier programs as well as characteristics that have been important in successful ones.

There are two main types of agricultural insurance, single and multiple peril coverage. Single peril coverage offers protection from single hazard while multiple peril affords protection from several. Hail and fire insurance are the most familiar types of single peril coverage. Private companies have covered these hazards because they conform to the prerequisites for insurability discussed in Chapter 1. Specifically, weather data are plentiful, it is relatively easy to measure losses, these risks are not highly correlated across farms and losses are accidental since farmers' actions have little affect on the weather experienced.

Multiple peril crop insurance has also been available for many years in some countries. Public institutions, such as the Federal Crop Insurance Corporation, have been much more involved in multiple peril insurance than is the case with hail or fire insurance. The reasons private insurers are generally not involved in multiple peril crop insurance are often couched in terms of an inability to develop a suffic

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sufficiently broad insurance pool. What seems more probable is that lack of data, an inadequate understanding of the complex interactions of the large number of environmental factors which affect yields, and the important role played by managerial decisions in the ultimate outcome, prevent an actuarial assessment of such risks. For example, the degree to which pests affect the yield of a crop is dependent upon a large number of environmental factors: the amount and timing of rainfall, atmospheric humidity, temperature, populations of insects and organisms which prey on the pest, the specific crop planted and so on. There is not a complete understanding of all the interactions between these factors. Furthermore, these environmental interactions are profoundly affected by a farmer's management decisions: the pest management system employed, use (or not) of irrigation, type of irrigation used, timing of planting, etc.

Because of the complexity of multiple peril insurance, there is greater public sector involvement. Revenue insurance is a type of multiple peril insurance. The list of hazards covered is simply extended to include market risks. Adding complexity to a system that is already but poorly understood leads to the conclusion that the public sector will surely be involved in a revenue insurance program. Because of the government's involvement, experience with multiple peril crop insurance is likely to be more instructive to an understanding of revenue insurance than is the history of single peril instruments. Therefore, this review will concentrate exclusively on the record of multiple peril insurance. First, the experience of other countries with crop insurance is examined. This will be followed by an examination of the history of crop insurance in the U.S.. The final part of the chapter looks at revenue insurance: what it is, how it might be structured, its goals and how it might work in the U.S.

Crop Insurance in Other Countries

A number of countries have experimented with various forms of crop insurance.[1] The crop insurance programs of Canada, Japan, France, Sweden and the United States will be discussed. This choice is dictated by the availability of information and the interesting insights and lessons offered by the history of each.

Crop Insurance in Canada

The Prairie Farm Assistance Act (PFAA) of 1939 was the first effort undertaken by the Canadian government in the area of crop insurance. This program gave limited protection to producers of grain in the wheat producing provinces of Western Canada but provided no protection to farmers producing other crops or to grain producers in other regions. The PFAA assessed a one percent levy on all grain marketed via the Canadian Wheat Board. Indemnities were paid whenever yields in a township fell below a given level. If yields in a township fell below the guaranteed level, all producers living in that township who grew that crop received an indemnity. The maximum amount any farmer could receive from PFAA was $800.00 per year.[2]

A much more ambitious program was launched in 1959 under the Federal Crop Insurance Act (FCIA). FCIA enables the federal government to enter into an agreement with a province to help provide crop insurance. Currently, the federal government will pay up to 50 percent of the administrative expenses of the crop insurance program, they will subsidize the premiums paid by farmers by up to 25 percent and they offer reinsurance services to the provinces.[3] Insurable crops include wheat, oats, barley, flaxseed, rye, seed corn, buckwheat, soybeans, potatoes, sugar beets, tobacco, sunflower, rapeseed, apples, plums, pears and apricots. These crops are insured against all natural perils. As each provincial policy is unique, this discussion will focus on the crop insurance program in Manitoba.

Manitoba was the first province to accept the federal government's offer to assist in setting up a crop insurance program. Less than two months after the federal enabling legislation was passed, Manitoba began a pilot program in crop insurance. In its first year of operation, 1960, the Manitoba program attracted more than 38 percent of the eligible farmers.[4] The Manitoba program offers crop insurance in any area where at least twenty-five percent of the farmers who own at least twenty-five percent of the cropped acreage indicate a willingness to participate in the program. Coverage is available at 50 percent, 60 percent and 70 percent of long term average yields. The long term average yield may be established on the yields of the individual farm or on the yields of all farms in the area in which the farm is located. The farmer also has price elections (which set the rate per bushel at which any compensation will be paid) to choose from. Premiums are based on the productivity and riskiness of the area and are subsidized by the federal government. Two other premium discounts are available. One, called an experience discount, rewards growers who have made no claims on their policy. The second is a size discount which lowers the premium by 5 percent when the insured acreage is 300 acres or more.[5]

The Canadian program has enjoyed a measure of success. It has attracted a relatively large proportion of the eligible farmers and has had a solid loss ratio, indemnities divided by premiums, of .88 over the years 1960 - 1975 when all provincial programs are taken as a whole.[6] Ray credits the success of the Canadian program to seven factors:

1. The provinces were given the initiative to start and run programs.
2. The federal government covered the cost of administration and a portion of the premium.
3. Crop insurance was the only form of disaster relief available to farmers in areas where it was offered.
4. Coverage increased over time with the rate of inflation and the cost of production.
5. Yields and coverage based on the experience of the individual farmers were used as much as possible.
6. Efforts were made to coordinate public, all-risk crop insurance and hail insurance to minimize duplication of coverage.
7. Good coordination with farmers needs and concerns was sought.[7]

The Canadian system is interesting because the program is run and structured, in large measure, by the individual Provinces. This is beneficial to the extent that programs can be tailored more closely to the individual needs of the farming communities within each province. However, it could lead to inequities across provinces. The Federal government, by coordinating and overseeing all agricultural insurance programs, seems to have minimized this problem.

Mention should also be made of another Canadian program aimed at stabilizing returns to farming, the Western Grain Stabilization Plan (WGSP). The WGSP covers wheat, oats, barley, rye, flaxseed and rapeseed. It guarantees that net cash flows to the region from sales made by the Canadian Wheat Board of the six crops mentioned above, will not be less than the average for the previous five years. Net cash flows are defined as gross receipts less cash costs of production. Participation in the program is voluntary. Each participating farmer contributes two percent of the value of his sales to the Canadian Wheat Board as a type of indemnity. The dollar amount of these contributions determines his share of any benefits disbursed by the WGSP. Both the indemnity and the premium are proportionate to the amount of production and do not reflect differing exposure to risk, across farms or crops.

Crop Insurance in Japan

The Japanese system was begun in 1938. The insurance covers crop losses caused by frost, flood, drought, wind, snow, insects, bird, wildlife and plant diseases. The minimum loss that must be suffered prior to making a claim is 30 percent. The proportion of the loss indemnified increases with the size of loss. For example, if between 30 percent and 40 percent of a farmer's crop is lost, he may apply for an indemnity that will cover at most 5 percent of the loss. For a loss of 90-100 percent, the indemnity will cover at most 50 percent.[8] Participation in the program is mandatory for all but the smallest farms.

There are three levels in the administration of the Japanese system. At the local level is the agricultural cooperative. The second level is composed of federations of local cooperatives. The role of the federations is to coordinate communications between the local and the national levels. At the national level representatives of the cooperatives have an advisory/lobbying role with the national insurance agency and the Ministry of Agriculture. The national organization manages a special fund used to cover unusually large losses.

The national government pays all the administrative expenses at the national level and a portion at the prefectoral and local levels. The government also pays a large proportion of the farmers premium. Premiums are based on the record of claims made by the cooperative as a whole over the previous 20 years.[9] The government's portion of the premium increases with the riskiness of the production area.

An interesting feature of the Japanese system is that premiums are constant across producers of a given crop in a given cooperative. The insurable yield, on the other hand, is determined for each plot of land with the maximum coverage being seventy-five percent of the established average yield.

The Japanese system is highly structured yet power is quite decentralized. A great deal of power is vested in the local agricultural cooperatives which sell policies, inspect and estimate reported losses, determine the average yield for each plot of land, collect premiums and disburse indemnities.

The Japanese system has the advantage of a high degree of farmer involvement in the operation of the program. The Japanese system for adjusting claims is particularly interesting. Local farmers who are well-respected members of the community determine losses and indemnities. This may increase confidence that the program is not being manipulated by an insurance company for its own profit. Communication between client and seller would also be expected to be facilitated in this institutional setting. This mechanism is also likely to result in inequities across cooperatives. For example, the rulings of the claims adjusters in one cooperative may be substaintially more generous than those of a neighboring cooperative.

There are other aspects of the Japanese program that seem counterproductive. In particular, the higher level of subsidization of premiums in high risk areas would be expected to encourage production in these areas. The explanation for this probably lies in the political importance of the farm vote in Japan and upon the aim of Japanese policy to achieve self sufficiency in food production. Another aspect of the program that is unusual is the manner in which premiums and level of coverage are calculated. It is unclear why premiums are calculated on a cooperative wide basis and coverage levels on a farm by farm basis when it appears that data exist for calculating a premium based on the experiences of the individual farm.

Crop Insurance in France

The first disaster relief program for farmers was begun in 1567 in France.[10] At intermittent periods since that time, France has tried programs of various sorts. From 1933 until 1942, for example, a special fund to protect farmers from losses caused by hail, frost, flood or hurricane was created. The system was halted because of the disruptions and fiscal crises caused by World War Two. As financial statements were not published, the performance of this program is difficult to evaluate quantitatively. Millot, however, cites five weaknesses of the program:

1. The indemnity calculation was complex and likely to be misunderstood by the farmer clients.

2. The process for making a claim on the policy was lengthy

and cumbersome. It took an average of two years to settle a claim which, on average, covered about fifteen percent of the loss.

3. Coverage was limited to the four hazards noted above.

4. There were no background studies done prior to implementation.
5. Solid financial backing was lacking.[11]

Not until 1964 was a new system of crop insurance enacted. The new plan created the "Central Bank for Reinsurance" (CCR), a Guarantee Fund, a National Commission and local "committees of experts". Within the CCR a committee composed of three members of the Ministry of Economics and Finance and three from the Ministry of Agriculture controlled investments made on behalf of the Guarantee Fund.

The National Commission, composed of farmers, insurers, and government administrators, was charged with data collection and analysis, disaster prevention efforts, overseeing money in the Guarantee Fund and managing the indemnification process.

The local committee of experts evaluated claims for indemnities within their county. They advised the prefèt, or head of county government, who was responsible for transmitting claims to the national commission. The local committee also suggested an amount to be paid to farmers who had submitted claims.

Funding for the program came from a variety of sources. Farmers paid a premium, the national government contributed an amount that at least matched the amount raised via premiums, local governments covered operating expenses and some revenues were generated from investments when premiums exceeded indemnities. Despite the variety of funding sources, funding was a problem in the early years of operation.

The premium was collected by adding a ten percent surcharge to a farmer's fire insurance premium and adding five percent to premiums paid by them for other types of insurance. This means of collection was adopted because it was easy to administer.

The French system is best described as discretionary. For example, it was felt that a list of perils covered would be too limiting, so it was left to the discretion of the National Committee to determine what constituted an indemnifiable loss. Another example would be the manner in which indemnities were determined. The National Committee decided how much it would give each county and published its ruling in the "Official Journal". A farmer with an outstanding claim then had twenty days in which to press his claim with the responsible insurance company. The insurance company passed the claim to the local expert committee who decided what proportion of the claim to pay.

One of the attractions of the French system is its remarkable degree of flexibility. The legislation authorizing the program indicated the general purpose of the insurance plan but did not dictate what should be deemed an insurable event or the rate at which compensation was to be granted. This flexibility allowed the administrators of the program to respond to new and unanticipated events. However, this flexibility was also one of the major weaknesses of the program. Like the Japanese system, the descretionary powers vested in the local committee of experts resulted in claims adjustments that were inconsistent across departments. In addition, the discretionary power of the national commission over the amount of indemnities granted each county appears to be highly susceptible to misuse and at a minimum would increase the uncertainty in the system.

There are a number of other problems with the French system. The system of taxing existing insurance policies as a source of revenue for the government's own program is counterproductive. By increasing the tax on all forms of insurance farmers will reduce the amount of insurance coverage purchased. As a result, revenues from premiums for the multiple peril insurance fall yet farmers become more dependent upon the government program for insurance protection. In operation, a lack of funds coupled with increased demands on the program, led to farmers' complaints about low levels of indemnification, the inability of the program to fulfill all of the tasks assigned to it and inability to extend the coverage offered. Furthermore, the system of indemnification was slow, complex and bureaucratic. The average elapsed time between a report of damage and receipt of an indemnity was estimated to be seven months.[12] The amount of compensation was small relative to the losses experienced. The law specified that the maximum proportion of a loss that could be compensated was 75 percent. Between 1966 and 1968 the proportion of loss covered by insurance was between ten and thirty-five percent.[13]

Crop Insurance in Sweden

In the Swedish system, begun in 1961, the basic unit of analysis is not the farm but the agricultural district, of which there are 400. The districts are drawn so as to contain as uniform a group of farmers as possible. Twenty-four district agricultural boards verify yields, determine premiums and pay indemnities to the agricultural districts under their sway. At the national level the administrative authority is the National Agricultural Marketing Board.

The government pays all administrative costs and two-thirds of the premiums. The remaining one-third is collected via taxes on crops marketed by agricultural cooperatives. For farmers with more than two hectares under cultivation, insurance is compulsory.

Compensation is based on the total value of output of a given crop for an entire district. If this total value is less than the value based on average yields then an indemnity is paid. This is similar to the Western Grain Stabilization Plan of Canada. Such a system is possible because all farm products are marketed by local cooperatives.

Coverage is offered for wheat, barley, rye, oats, oilseeds, potatoes and sugar beets. In addition, four year contracts are offered on livestock by the Scandinavian Livestock Insurance Company. In all cases the insurance is multiple peril.

The Swedish system, which pays benefits based on averages for the agricultural district seems unlikely to be either an equitable or an efficient way of providing protection from the risks faced by farmers. Such a system produces the anomalous result that a farmer in a given district could experience an above average year yet receive an indemnity if his fellows in the district had sub-par years. Furthermore, even if the agricultural districts are initially drawn to ensure the maximum degree of homogeneity possible, it seems unlikely that this is wholly achieved. This is even more unlikely when considered in a dynamic context. This being the case, the insurance needs of farmers in the district are likely to be different. The lack of a direct connection between individual actions and rewards (indemnities and premiums) is unlikely to provide the sort of performance a policy maker is after.

Conclusions Drawn from the Programs Discussed

The conclusions drawn from these brief historical sketches are that chances for a successful insurance program are enhanced when policies reflect the individual farmer's experience as directly as possible, when the terms of the policy are clearly enunciated, when claims are adjudicated and settled promptly and when there are few (no) close substitutes for the type of protection offered by the public insurance program. In particular, it is important to link the cost of protection to farm management decisions that influence exposure to risk.

Having seen how systems in other countries work, the next item of business is to examine the U.S. system of crop insurance.

Crop Insurance in the United States

Several comprehensive histories of crop insurance in the U.S. already exist and interested readers are directed to them for further information regarding this program.[14] The intent of this section is to summarize the current program and the performance implications of some of its key components.

Crop insurance contracts are available in 1,526 of the 3,077 counties in the United States. Claims have been paid on losses resulting from 119 different causes. Drought has been the most frequently cited cause of loss, accounting for 41.5 percent of all claims paid. Other losses covered by FCIC and the frequency of occurrence include excess moisture (15.9 percent of claims), frost (13.9 percent), hail (10.9 percent), wind (6.7 percent), insects (4.6 percent), disease (2.8 percent), flood (2.2 percent) and all other (1.6 percent).[15] Proponents of the crop insurance program argue that by helping to insure a minimum level of output, it facilitates forward contracting, access to credit, capital formation and investment decisions.

In the following pages the U.S. crop insurance program will be examined. Crop insurance is more like revenue insurance than any program with which the U.S. has had experience. There are, however, important differences between the two programs. The most obvious is that revenue insurance would insure the combined price and yield distributions rather than yields alone. Nevertheless, the experience with crop insurance is likely to yield valuable lessons to anyone interested in a revenue insurance program.

The Current Crop Insurance Program

In 1980 several important amendments were made to previous legislation regarding crop insurance. The most important change made in 1980 was with respect to FCIC's mandate. In 1980 it was decided that all-risk crop insurance would replace disaster payments as the main form of disaster relief in U.S. agriculture. Starting in 1974 and lasting until 1981 the federal crop insurance program was in direct competition with the disaster payment program. Disaster payments were available for most grains and cotton. They were, from the farmers' point of view, the perfect insurance policy, one in which no premiums were charged yet indemnities were substantial. Because of budgetary constraints and what was perceived by many as the inequity of the disaster payment system, the program was halted in 1981. Crop insurance was to pick up the slack. The expanded role of crop insurance was emphasized by the goal of FCIC to insure 60 percent of eligible acreage by 1984.[16]

Prior to 1980 FCIC all-risk crop insurance had been sold by Agricultural Stabilization and Conservation Service (ASCS) field offices. Since then, all sales of crop insurance have been handled by private insurance companies who reinsure all policies with FCIC.

An important 1980 reform was the expanded use of the Individual Yield Coverage (IYC) plan. Under this plan a farmer who wishes to have his coverage based on his actual historical experience may do so by submitting three years of verifiable yield data from his farm. This is averaged with seven years of county data to determine the average yield for the farm and the insured yield. Each subsequent year in which that crop is grown, a year of farm data is added to the formula and a year of county data removed. After seven years, the average yield calculation is based entirely on the farmer's experiences.

A farmer wishing to purchase crop insurance must sign up early in the cropping cycle. Generally, a contract must be signed by the end of April. The contract will specify dates by which various farming activities must be completed and acreage reports filed. For instance, grain corn in Michigan has to be planted no later than June 10 and harvested no later than December 10 for the policy to be valid. These dates may be relaxed by FCIC in the advent of unusual conditions. Having planted his corn, the farmer must inform FCIC by June 30 how many acres are involved in a given contract. If the farmer wants to cancel an existing policy he must inform FCIC by December 31 of this intent, otherwise, the policy is automatically renewed.

Conclusions Drawn from the Experiences of FCIC

The FCIC program has not been without problems. Probably its most significant problem has been with participation rates. In some areas, particularly the wheat producing states on the High Plains and dry land cotton areas in Texas, participation rates have been high. In large parts of the Corn Belt, on the other hand, participation is almost nonexistent. In the Corn Belt, better managers tend not to buy crop insurance because it offers them little protection. The level of protection offered could be low for at least two reasons. First, management and/or environmental factors are such that a decline in yields sufficiently large to trigger the insurance policy is very unlikely. Secondly, the reliance upon county averages in determining the level of protection adversely affects the better than average producer. For example, suppose the average yield for corn grown on first quality land is 100 bushels per acre in county X. A policy guaranteeing 75 percent of average yields guarantees an average farmer that if his yields fall 25 percent or more below his average yields he will receive compensation from FCIC. For an above average producer whose average yield is 125 bushels per acre, yields would have to fall 40 percent below his average to be entitled to an indemnity from FCIC.

The result, many believe, is that FCIC suffers from an adverse selection problem in the Corn Belt. Farmers, at least, seem to believe participants in the program are farms with lower quality land and management.[17] An indication of this is that Production Credit Associations require some of their higher risk clients to purchase a crop insurance policy as a prerequisite for a loan.

A significant difference between the actual average yield of an above average farmer and the yield ASCS has established for his farm could occur either because he has failed to report his yields to the ASCS office each year or because the quality of his land is significantly better than classified by ASCS. Even if the farmer opted to participate in the IYC program, the attractiveness of crop insurance would not change drastically. Suppose this above average farmer submitted three years of data showing he averaged 125 bushels/acre over the period. This is averaged with seven years of county data (100 bushels/acre) to determine the insurable level. In this case his adjusted average yield is 107.5 bushels/acre which means the maximum insurable yield is 80.625 bushels/acre. Therefore, even with the IYC

program our farmer would have to suffer a decline of over 35 percent to be eligible for a benefit from FCIC. These calculations are shown below.

(1) Adjusted average yield = [(125 X 3) + (100 X 7)]/10

= 107.5 bushels/acre

(2) Maximum insurable yield = 107.5 X .75

= 80.625 bushels/acre

(3) Percent fall for benefit = (125 - 80.625)/125

= 35.5 percent

If this farmer has a three year crop rotation, meaning he grows corn every third year on the farm in question, twenty-one years will pass before he will be able to provide seven years of yield data from his farm. If there is any sort of trend in yields, the ten years of data from his farm will not give a very accurate picture of his current ability to produce corn.

A second problem is that use of county data cannot capture differences in the variability of yields on two farms. Suppose two farmers, Jones and Smith, have the same expected yield but the variability of Smith's yields is much greater. Figure 2.1 compares the probability density function (PDF) of yields for Jones and Smith. Suppose both select a policy from FCIC which guarantees them 75 percent of their average yield, a much greater proportion of Smith's PDF is covered than Jones' (The area a_S is much larger than the area a_J). If Jones and Smith are signing up for insurance for the first time and have land of similar quality, they will pay similar premiums. The program will be much more generous to Mr. Smith since he will receive indemnities more frequently and the size of his indemnities will, on average, be larger. Normally the premium paid by Smith would be expected to be much higher, reflecting his more variable experiences. FCIC premiums do, in fact, adjust over time to reflect such differences but only slowly. There seems to be no explicit inclusion of the proportion of the PDF covered in the premium calculation formula.

Having developed this background in crop insurance, the discussion now turns to the specific elements of a revenue insurance program.

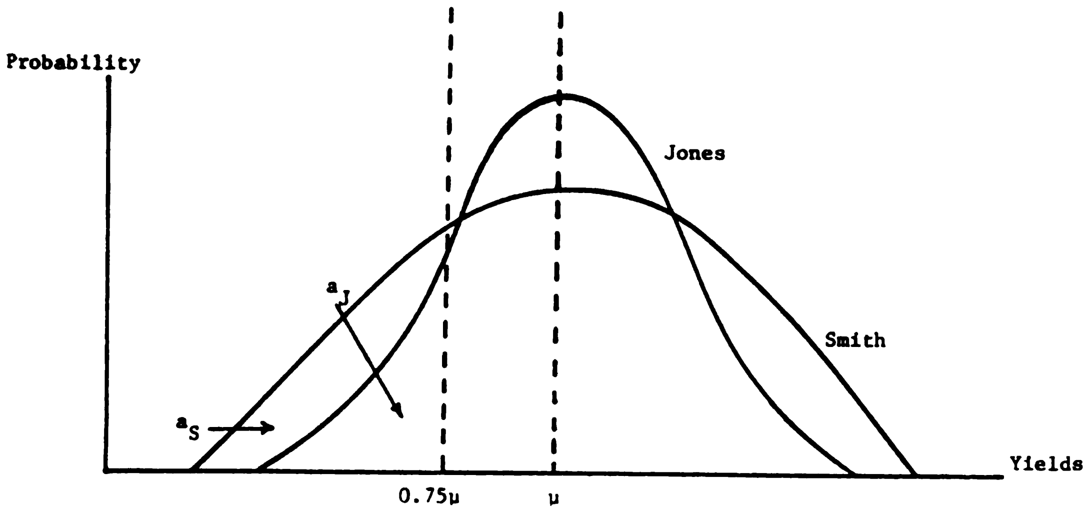

Figure 2.1: Comparison of Smith's and Jones' PDF.

The Prospective Revenue Insurance Program

The idea of revenue insurance for farmers is not new. In the late 1950s and early 1960s it was discussed in the academic journals.[18] At that time revenue protection for farmers was proposed as part of a comprehensive social insurance program and would have compensated farmers in a manner comparable to workmen's compensation. The current discussion of revenue insurance takes a somewhat different tone. The 1981 Farm Bill called for the creation of a task force to determine, "whether such a concept (as revenue insurance) might provide the basis for an acceptable alternative to the commodity price support, income maintenance and disaster assistance programs currently administered by the Department of Agriculture . . .[19] The task force was duly formed and presented its recommendations to the United States Congress in June of 1983. The recommendations of the task force will provide a starting place for this description of a revenue insurance program.

The Task Force Recommendations

The task force listed fifteen characteristics they felt a revenue insurance program should possess. Table 2.1 summarizes these characteristics.

Most of the ideas contained in the table are hard to fault. The same cannot be said of the means they proposed to implement their ideas. The outlines of the revenue insurance program envisaged by the task force are as follows. First, they would offer coverage on a crop by crop basis. Thus, a farmer could insure 75 percent of his average

Table 2.1: Characteristics of an Ideal Revenue Insurance Program As Proposed by the Revenue Insurance Task Force.

1. It should be actuarially sound.
2. It should be based on the yields of individual farmers and prices in a well defined market area.
3. It should offer coverage on all crops or agricultural products currently covered by a government program. Additional types of output should be covered as practical.
4. It should be designed to attract a large number of eligible farmers.
5. The program should be easily understood and administered.
6. Moral hazard and adverse selection should be minimized.
7. Imprudent risk taking should not be encouraged.
8. Government expenditures and involvement in the agricultural sector should be minimized.
9. No more than 100 percent of cash costs of production should be covered.
10. Coverage in an area should be offered only on products proven to be commercially viable.
11. Disruption of related markets caused by the program should be minimized.
12. Price signals should not be distorted.
13. It should complement and not substitute for existing insurance options.
14. It should be flexible enough to accommodate changes in productivity and production practices.
15. Sound management practices should be followed and isolation from the political arena sought.

revenue from his corn crop and, if he wanted to, 50 percent of his average revenue from soybeans. Second, coverage would be offered for multiple year periods. For example, if farmer Jones wanted to guarantee a revenue level from his corn crop he would have to buy a policy covering the next three cropping seasons. Third, the Task Force recommended use of farm data for yields but an average market price from "a well-defined market area", to determine the revenue earned by a participating farmer in a given year. Fourth, premiums charged for this protection would be sufficiently high to cover indemnities and administrative costs. Fifth, the guaranteed return would not exceed the farmer's cash costs of production. Sixth, the program would be run entirely by private insurance companies. Private insurers were felt to be more efficient managers of insurance programs. It was also argued that private insurers are held in higher esteem than government bureaucrats by the farm population.

An Alternative Program Formulation

The program analyzed in this dissertation differs from the Task Force program in several significant ways. Table 2.2 summarizes my assumptions about the form a revenue insurance program should take. Coverage should be based on gross farm receipts from all farming activities, not on a crop by crop basis. Production costs and off-farm income would not be considered in calculating protection levels. Coverage would be offered at various proportions of the average real gross receipts earned from each crop cycle over the past ten years. The levels of 50 percent, 60 percent and 75 percent were used in this study. Gross receipts would be calculated as sales of the current year's output plus or minus changes in the value of inventories held. Inventories would be appraised at year's end using six-month contracts on the futures market, if available, or the current market price for the commodity if a futures market for it does not exist. Premiums paid by farmers would be calculated on the basis of the frequency and size of benefits received and would, at a minimum, cover indemnities. Policies would be marketed and serviced by private insurers and reinsured by the federal government.

Table 2.2: Summary of the Alternative Revenue Insurance Program

1. Coverage for gross revenue from all farming activities.
2. Coverage offered at 50, 60 and 75 percent of average gross revenue.
3. Base period for estimating coverage is 10 years.
4. Premiums based on frequency and size of payouts.
5. Premiums at least cover indemnities.
6. Inventory changes evaluated at year's end using agreed upon formula.
7. Coverage and premiums calculated from farm data.
8. Coverage should be adjusted to account for inflation.
9. Policies sold by private insurance companies.
10. Policies reinsured with the federal government.

Justification for Alternative Formulation

This discussion must start with a justification for insuring gross farm receipts rather than gross receipts from a single crop. There are at least three reasons for this approach. First, gross farm receipts is a variable much closer to the one of primary concern to most farmers, net profits, than is gross receipts from a single crop. Therefore, a program guaranteeing a given level of gross receipts is more likely to be of interest to a broader cross section of farmers than one guaranteeing gross receipts from a single crop. Second, insuring returns from a single crop could easily promote behavior I would consider counterproductive. Two hypothetical situations should suffice to illustrate this point. Consider a farmer faced with a situation in which two of his crops require immediate attention because of an infestation of pests. If one crop is insured and the other is not, which crop will receive the needed attention? In case two a farmer is considering revenue insurance for one of the two crops he produces. Based on past experience, he knows that crop "a" produces very little revenue once every 3 or 4 years while crop "b" has a similar experience once every 20 years. Our farmer is much more likely to purchase insurance on crop "a". This could mean that the insurance pool is filled with bad risks, in which case the premiums required to cover indemnities would skyrocket and the program fail.

The third justification I would offer for using gross farm receipts is that this would allow the insurer to take advantage of the revenue experiences of different types of output that are unlikely to be perfectly positively correlated. For instance, if a farm produces corn and soybeans, a bad revenue year for corn may be wholly or partially offset by a better than average year for soybeans. This will reduce the cost of a revenue insurance policy. The implication of this formulation is that risks are spread across types of crops and across time. This feature should facilitate the pooling of the hazards faced by the farm population.

The justification for seeking a premium that, at a minimum, covers indemnities rather than one covering all costs is two-fold. First, in the early years of the program it will be important to maximize participation levels to increase the probability that premiums do cover indemnities. As a new policy direction, revenue insurance is bound to face considerable hostility from farmers and from those with vested interests in the current programs. Acceptable participation rates are more probable if the price of insurance is kept down. Good participation is also necessary to maintain the political will to continue the program. If the program experiences large losses initially and few farmers participate, revenue insurance could suffer the same fate crop insurance did in its early years (cancellation, reduction in scope, etc.). An insurance program requires continuity to function properly. Insurance works because the seller can use the long term probabilities facing his clients to cover a portion of their risks. In addition, continuity promotes farmer confidence in the program.

The government should be involved because it is unclear that a private company could or would offer this form of insurance on its own. As noted at the start of this chapter, it is difficult to envisage a private insurer offering revenue insurance. Currently we lack the data and the understanding of the complex interaction of forces that determine a farmer's revenue.

Some have suggested that insurance companies might offer this type of coverage if option markets were available to allow insurance companies to shift some of the risk they would be assuming by writing a revenue insurance policy. This is not likely to be true even if revenue insurance is offered on a crop by crop basis (and is less likely if it is offered on a whole-farm revenue basis). An options market would allow an insurance company to protect itself against intra-year but not inter-year price movements. There is a very basic conflict between the types of protection offered by revenue insurance and an options market. An options market allows a participant to put a floor (if a seller) or a ceiling (if a buyer) price on the commodity with which he is dealing. The protection is against price movements in the near future. In essence, an options market is designed to shift risk bearing responsibilities caused by exogenous events which affect market prices within a given cropping season. Clearly, longer term options could be written but as the length of time covered by the options contract increases, the cost of purchasing the option would be expected to increase dramatically.

A revenue insurance policy, in contrast, is offering protection from major deviations from longer term trends. In addition, the program discussed in this thesis is based on coverage for total farm earnings. Since many farmers produce more than one type of crop, option contracts would have to be taken out on each of the crops produced to offer the insurer comprehensive protection. Obviously the transactions costs increase substantially in this case.

An additional reason for governmental involvement is the danger that a relatively wide-spread phenomena, such as last year's drought in the mid-West, could threaten the economic viability of a private insurer who had issued many policies in the affected region. Finally, the government is almost certain to be involved in the data collection efforts needed for the successful operation of the program.

Cost of coverage should be based on farm data so that premiums charged reflect the individual management decisions of the client. This is not likely to be possible in the extreme; the premium for each farmer will not be calculated using a unique formula. It is conceivable that different classes of farmers will have their premium calculated differently.

The level of coverage should also be adjusted to account for inflation. This is particularly important if a relatively long base period is used since the dollars earned in the early years of the base period will be relatively more valuable than those earned in the current period.

Allowing private insurers to market and service revenue insurance contracts while offering a governmental reinsurance option has several advantages. First, since an insurance agent has an on-going relationship with a farmer and is accustomed to explaining insurance contracts, they may be effective conduits of information about the new program. Second, since revenue insurance would be expected to supplant other forms of agricultural insurance, giving private insurers an economic stake in revenue insurance might defuse the expected opposition of the insurance companies to the program.

Finally, the adminstrative details of the program, such as the length of the base period and the coverage levels offered should be open for debate. They are, to a large extent, empirical questions. The base period, for example, should be sufficiently long to provide an accurate picture of the farmer's earning potential. If it is too long, however, its ability to adust to changing conditions is reduced. The level of coverage offered should be neither so high as to "guarantee" success nor so low as to fail to offer a meaningful level of protection. The levels chosen for this analysis should be seen as a starting point for discussion.

Having summarized and justified the assumptions employed about the structure of a revenue insurance program, I will proceed with a discussion of the theory of insurance.

1. Countries who have or have had crop insurance programs of some sort include: Canada, Chile, France, Greece, Israel, Japan, Mauritius, Mexico, Poland, Spain, Sri Lanka, Sweden, the U.S.A. and the U.S.S.R.

2. Canada, Report of the Federal Task Force on Agriculture, "Canadian Agriculture in the Seventies", Page 390.

3. P. K. Ray, 1981, Page 194.

4. Ray, ibid. Page 198.

5. Ray, ibid, Page 200.

6. Ray, ibid, Page 202.

7. Ray, ibid, Page 204.

8. Roger Henri Millot, 1969, Page 278.

9. Beatriz Benilde Gàlan, 1981, Page 14

10. Millot, op. cit., Page 121

11. Millot, op. cit., Page 128-129

12. Millot, op. cit., Page 177

13. Millot, op. cit., Page 179

14. Krammer, 1982 and Gardner and Krammer, 1982, two recently published summaries of this experience, are quite good.

15. United States, U.S.D.A., An Inside Look at Crop Insurance", March 1980.

16. Vernon L. Sorenson, March 1982, Page 1.

17. Walker, Odell, 1982, Page 1.

18. See Swerling, 1959, for an example of this discussion.

19. United States, U.S.D.A., "Farm Income Protection Insurance: A Report to the U.S. Congress", June, 1983, Page 33.

Chapter 3

A Summary of Empirical and Theoretical Studies of Insurance: The Economic and Psychological Schools

The extensive literature on the behavior of individuals choosing insurance may be divided into two schools of thought. One school is psychological in nature, the other is economic. Psychologists attempt to determine people's behavior in risky situations by asking them about their preferences or observing their actions in such situations. Economists prefer an axiomatic approach; inferring actions from assumptions about behavior.[1] This chapter will review a subset of the models employed and conclusions reached by authors from both schools of thought.

The Economic Approach

The economics literature in economics dealing with insurance can be divided into four parts: theoretical models of insurance demand, theoretical treatment of insurance supply, empirical investigations of insurance demand and empirical work on insurance supply.

Theoretical Models of Insurance Purchases

Of the demand models reviewed here, most introduce uncertainty by considering an ex-ante decision when two outcomes are possible. Outcomes are dependent upon the state of nature that prevails after the decision is made. The outcome associated with one state of nature will be less favorable than the outcome associated with the other. A few studies refine this slightly by introducing a stochastic loss function producing outcomes of varying degrees of utility.

As an example of these two state models, suppose you are a farmer in the kingdom of Oz. The climate in Oz is such that twenty-five percent of the time a frost occurs during the night of April 20th. Otherwise, frosts do not occur in Oz. As an Ozian farmer, you know that if there is no frost, planting corn on April 1st will result in yields ten percent greater than those attained if you wait until April 20th to plant. If a frost does occur, replanting is necessary and costs increase by seventy-five percent. The ex-ante decision on April 1st is how many acres, if any, should be planted. The favorable/unfavorable state is no frost/frost.

Ahsan, Ali and Kurian develop a two state model with risk averse buyers of insurance and risk neutral sellers. Assuming a zero profit level for insurers, they maximize the following expression:

$$\text{Maximize } V = (1-p)U(Y_1) + p(U(Y_2)) \qquad (3.1)$$

$$\text{Subject to } W = a(qA - pF(A)) = 0 \qquad (3.2)$$

Where

V = Buyer's expected utility.
U = Buyer's utility function.
W = Seller's profit function.
p = Probability of an unfavorable event.
Yi = Income earned in state i, i = 1,2.
F(A) = Farm's output or production function.
A = Resources devoted to risky production.
q = Premium rate.
W = Profits.
a = Insurance coverage ratio.

Equation (3.1) states that the utility of the farmer is the sum of the utility associated with the favorable outcome times the probability that the favorable state occurs and the utility of the unfavorable state times the probability it occurs. The authors solved this model to determine optimal insurance choices and found that risk averse farmers will purchase full insurance[3] if it is offered at an actuarially fair price[4]. With full insurance more resources go into the risky asset than when full insurance is not available. If returns to the risky asset experience a mean preserving spread, allocation of resources to the risky action choice will decline. A mean preserving spread is a change in the PDF which leaves the mean unchanged while increasing the variance. As initial wealth or the minimum level of insured income increase or as the risky action choice experiences a risk-preserving increase in the mean, more resources will go into the risky option. A risk-preserving increase in the mean holds the shape of the PDF unchanged while shifting the entire distribution outward.

Ehrlich and Becker also use a two-state model in their examination of the relationships between market insurance, self insurance and self protection. Their basic model is similar to equations (3.1) and (3.2). However, the definition of income in the two states and the constraint change, depending upon the risk reducing options available to the decision maker. Thus, if only market insurance is available, the income expression and budget constraint are different than if self protection is the only risk reducing option. In all cases, the models are solved to determine the implications of and relationships between the various forms of protection. The authors first look at the characteristics of market insurance. They also conclude that full insurance will be purchased if available at an actuarially fair price.

In examining the impact of an increase in the premium, Ehrlich and Becker suggest that the premium be thought of as the rate at which a consumer is willing to trade income in the favorable state for more income in the unfavorable state.[5] Viewing the price of insurance in this way allows them to analyze the purchase decision using standard consumption theory. In Figure 3.1 the impact of an increase in the price of insurance is presented graphically. The initial equilibrium is at point a, the point of tangency between the iso-utility curve U_1 and the income transfer line DE. With an increase in the premium, the cost of maintaining income in the unfavorable state, Y_1, increases, and the transfer line becomes DF. To arrive at the new equilibrium, point c, income and substitution effects can be identified. The substitution effect moves the consumer from point a to point b, the point of tangency between the iso-utility curve and the income compensated budget line, IH. The income effect moves him to point c. The substitution and income effects are both negative when income in the unfavorable state becomes relatively more expensive to maintain. As a result, demand for income in state 1 decreases and less insurance is purchased. The impact of an increase in the premium on demand for Y_2, income in the favorable state, is ambiguous. As the authors point out, "although an increase in . . . (the premium) . . . reduces the amount of insurance purchased, each unit purchased becomes more expensive."[6] Therefore, the impact on income realized in the favorable state and on the amount spent on insurance will depend upon the elasticity of demand for insurance.

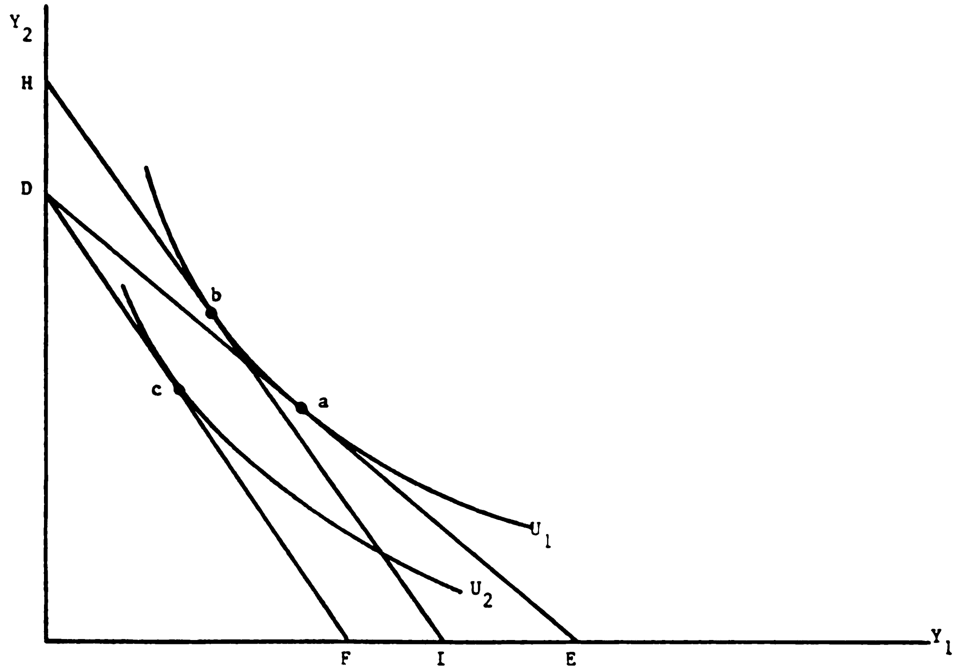

Figure 3.1: Income and Substitution Effects for Insurance Purchases

Erhlich and Becker also examine the impact of a change in the initial wealth position of the decision maker on demand for insurance. They derive the interesting conclusion that the effect of an increase in wealth depends upon how the increase is distributed between the two states of nature. If wealth in both states increases by the same percentage and the slopes of the indifference curves are constant along a ray from the origin (implying constant relative risk aversion), no change in the amount of insurance demanded will be observed. If wealth only increases in the favorable (unfavorable) state, demand for insurance will increase (decrease).

If market insurance is not available, a decision maker will engage in self insurance if it increases the income he will realize in the unfavorable state and if the price is less than the probability weighted ratio of the marginal utility of income in the bad state to the marginal utility of income in the good state. Self insurance will increase as the marginal productivity of such expenditures increase or as the endowed level of income in the unfavorable state falls. Ehrlich and Becker conclude there is little incentive to self insure against low probability events because the price of self insurance is "independent of the probability of loss."[7]

Changes in model parameters affect demand for market and self insurance differently if both options are available. Thus, if demand for market insurance increases in response to a decrease in income in the unfavorable state, demand for the substitute, self insurance, will fall. Ehrlich and Becker also conclude that a decrease in the probability of the unfavorable event will decrease the demand for self insurance and increase demand for market insurance. This result derives from their assumption that the price of market insurance, unlike the price of self insurance, is related to the probability attached to the unfavorable state of nature. They conclude that people will use market insurance to protect themselves against low probability events. Finally, if market insurance is available at an actuarially fair price, and self insurance is also available, they predict that behavior resembling risk neutrality should be observed. Decision makers, in this case, choose action choices that maximize expected income. The authors conclude that "apparent attitudes toward risk are dependent upon market opportunities, and real attitudes cannot easily be inferred from behavior."[8] Robison and Lev (1984) makes a similar point.

Finally, the relationship between self protection and insurance is explored. Ehrlich and Becker indicate that insurance has two opposing effects on self protection. To the extent that insurance reduces the difference between favorable and unfavorable outcomes, the incentive to engage in self protective actions is diminished. However, if the price of insurance is inversely related to the level of self protection, there is an incentive to increase expenditures on self protection. Thus, self protection can be either a substitute for or a complement of insurance.

To gain insights into intertemporal choices involved in purchasing insurance, Viscusi developed a two state, comparative statics model in which decision makers maximize their subjective utilities over two periods. In his model, insurance premiums are exogenously determined. The two states are accident and no accident and the insurer can monitor only the outcome, not the extent of self protection practiced. Table 3.1 summarizes Viscusi's results.

Viscusi found that to the extent a buyer can determine the likelihood of having an accident, his average income will rise because he will reduce expenditures on self protection and will selectively purchase insurance. For similar reasons, Viscusi found that as the mean of the accident likelihood distribution becomes larger and the variance smaller, the insurance buyer will purchase more insurance and practice less self protection. The impact of these changes on average income will be ambiguous. Table 3.1 tells us that as the future-mindedness of individuals, as represented by a fall in the discount factor, increases, so will their purchases of self protection. An increased concern for the future means the buyer will be sensitive to potential increases in his insurance premiums. To reduce the likelihood of increased premiums, expenditures on self protection are increased. An increase in the discount factor has a negative impact on average income and purchases of market insurance. Particular attention should be drawn to the pattern of responses with respect to insurance and self protection. Table 3.1 indicates "all unambiguous effects of parameter changes have opposite impacts on (the level of) self protection and insurance (purchased)."[9] The implication is that any manipulation of parameters can increase either the extent of self protection or the amount of insurance purchased but not both simultaneously. This result seems to contradict Ehrlich and Becker who concluded that self protection and insurance could be substitutes or complements. The results are actually consistent. Viscusi assumes the price of insurance goes down as expenditures on self protection go up. Ehrlich and Becker allow for independence between these factors but show that if they are negatively related they will be substitutes.

Table 3.1: Summary of Viscusi's Comparative Statics Results[10]

Increase in Exogenous Variable	Effect on Y1(a)	Effect on Y2(b)	Effect on Self Protection Expenditures	Effect on Market Insurance Expenditures
Sharpness of Prior Assessment of Accident Likelihood	+	0	-	+
Beta Distribution Factor(c)	+	-	-	+
Discount Factor(d)	-	0	+	-
Price of Insurance, Period 1	?(e)	?	?	?
Price of Insurance, Period 2, no Accident in 1	+	0	-	+
Price of Insurance, Period 2 Accident in 1	-	0	+	-

(a) Y1 is income in period 1.
(b) Y2 is income in period 2.
(c) Beta-distribution factor defines the mean and variance of the probability of an accident.
(d) = 1/(1+r) where r is the interest rate.
(e) ? = ambiguous effect.

The final three lines of Table 3.1 illustrate the importance of merit pricing. Viscusi argues that the price of insurance in the first period will have an ambiguous impact on both insurance purchases and self protection efforts because this price is independent of individual action. Indeed, the main impact of raising the price in the first period is to discourage low risk people from purchasing insurance resulting in a problem with adverse selection.[11] What is of more importance in Viscusi's model is what happens in the second period. If merit pricing is not practiced, where merit pricing implies that premiums are raised or lowered in accordance with the accident record, then the problems of adverse selection and moral hazard[12] are magnified. This agrees with results obtained by Ehrlich and Becker.

A very different approach to analyzing insurance purchase decisions has recently been proposed by Heiner. Heiner's thesis is that human behavior can be understood and predicted "only to the extent that uncertainty prevents agents from successfully maximizing."[13] Central to his argument is what he terms the 'Competence-Difficulty' or C-D Gap. The C-D Gap is the difference between the competence of the decision maker and the difficulty of choosing the alternative which would maximize his utility. While most economic analysis assumes the C-D Gap is zero, Heiner argues this is rarely the case and a positive C-D Gap causes 'flexibility constrained behavior'. Both environmental variables, such as the complexity of the situation, the stability of relationships and the likelihood of occurrence, and perceptual variables, such as differing abilities to decipher relationships, contribute to the C-D Gap. Heiner develops a 'reliability condition' which sorts situations into groups calling for flexible or inflexible responses on the part of the decision maker. The mathematical expression for this reliability condition is:

$$r(U)/w(U) > [l(e)/g(e)][(1-\pi(e))/\pi(e)] \quad (3.3)$$

or

$$r(U)(g(e)(\pi(e))) > w(U)(l(e)(1 - \pi(e))) \quad (3.4)$$

Where:

r(U) = Conditional probability of choosing a new action choice at the appropriate time.
w(U) = Conditional probability of choosing a new action choice at an inappropriate time.
l(e) = Loss in performance associated with w(U).
g(e) = Gain in performance associated with r(U).
$\pi(e)$ = Probability that the right time to select a new action choice occurs.

The ratio on the left side of the inequality in (3.3) is referred to as the reliability ratio and the one on the right is called the tolerance limit. The reliability ratio measures the decision maker's ability to make the correct decision at the correct time. The tolerance limit measures the expected cost that must be incurred (for a given reliability ratio) to induce action on the part of the decision maker. When the strict inequality in equation (3.3) does not hold, a decision maker should not invest time and money exploring the available options; current standard operating procedures should be maintained.

Heiner draws four behavioral generalizations from the reliability condition. First, action choices which would be preferred in rarely occurring situations are excluded from a decision maker's choice set. Second, over time the set of action choices available will "tend to produce rules that systematically restrict the flexibility of behavior"[14] and will not approach optimizing behavior. This concept might be compared to the systems science tenet that the optimal performance of the system as a whole is rarely achieved by maximizing in a single time period or over a specific subcomponent of the larger system. Third, behavioral patterns that are counterproductive may persist even though the cost of this behavior may be high. In terms of equation (3.3), a rule for behavior may persist despite a large r(U) if is small. In the operant conditioning terms of Skinner, aberrant behavior can persist even in the face of powerful disincentives if a negative reinforcer is not received. Finally, Heiner argues that the greater the degree of uncertainty the more predictable behavior. In equation (3.3), an increase in uncertainty decreases r(U) while increasing w(U).

With respect to the insurance purchase decision, Heiner's model indicates that people will be unlikely to insure against events with a low probability of occurrence. Heiner argues this is the explanation for the observed reluctance of home owners on flood plains to purchase federal flood insurance at lower than actuarially fair rates. As Heiner puts it, "as the probability . . . of a disaster goes to zero, the number of such extremely rare but conceivable events grows indefinitely large. Given any positive set-up costs of insuring against each of these possibilities, the total insurance cost will eventually exceed a persons's (finite) wealth."[15] As (e) gets small, the tolerance limit gets quite large and the reliability ratio must be very large if insurance is to be purchased to cover the hazard. But, at the same time, rare events are likely to reduce the decision maker's reliability ratio.

Heiner's results run counter to those of Ehrlich and Becker in at least one respect. Ehrlich and Becker argued that insurance demand will increase as the difference between good and bad outcomes increases. Heiner makes the quite reasonable point that it is not simply the dollar difference between the two but the probability weighted difference. Thus, the difference between good and bad states could increase yet, if the probability of the bad state occurring drops to near zero, the demand for insurance could decrease. Heiner does not examine the relationship between market insurance and other mechanisms for protection.

Empirical Models of Insurance Purchases

In examining the U.S. experience with crop insurance, Gardner and Krammer conclude that the program has suffered from adverse selection, has substituted for diversification and is used more heavily by part owners (whom they hypothesize are more highly leveraged) than by tenants or full owners. Using regression analysis, they found the expected rate of return to be significant and positively correlated with participation rates. They also found evidence to support the hypothesis that recent experience with crop insurance was more important in the purchase decision than longer term experience with the program.

Like Gardner and Krammer, Walker found that farmers view crop insurance as an investment. Hence, he would expect greater participation if the return on investment increased. Walker also concluded that the relationship between a farm's cash flow position and insurance purchases could be positive or negative. If lenders forced farmers facing cash flow problems to purchase insurance as a prerequisite for a loan, the relationship would be positive.

Otherwise, he expected a negative relationship.

King and Oamek estimated that purchasing the highest level of protection from FCIC (75 percent of yield and the highest price election), would increase the variable costs of dryland wheat farmers in Colorado by 30 percent.[16] They hypothesized that such a heavy burden decreases participation. In another paper also dealing with dryland wheat farmers in Colorado, King reported the results of a simulation model that used stochastic dominance with respect to a function and interval risk preference measures to order insurance choices and to examine the impact of changes in model parameters. His model was reasonably successful in predicting the actual choices of farmers. He found that changing the price of insurance by plus or minus ten percent had little impact on participation. Basing premiums on actual farm experience increased farmer participation in the insurance program.

Finally, Attansi and Karlinger examined the impact of the absolute risk coefficient on demand for flood insurance. The authors found that an increase in this coefficient was associated with a shift out in the demand for flood insurance and a decrease in price elasticity. Furthermore, they found the absolute risk coefficient to be positive (implying risk aversion) and fairly constant across the towns in their survey.

Theoretical Models of Insurance Sales

Raviv, using the following model, examines the optimal form for an insurance policy :

$$\text{Maximize} \quad E(U(W + I(x) - p - x)) > E(U(W - x)) \qquad (3.5)$$
$$\text{Subject to} \quad E(V(W_0 + p - I(x) - C(I(x)) > V(W_0) \qquad (3.6)$$

Where:

$U(W)$ = Utility function of a consumer. $U' > 0$, $U'' < 0$
$V(W)$ = Utility function of an insurer. $V' > 0$, $V'' < 0$
W_0 = Initial wealth of insurer

W = Wealth of consumer
$I(x)$ = Indemnity schedule with $0<I(x)<x$ and $I(0) = 0$
p = Premium
x = Loss
$C(I(x))$ = Cost of providing insurance. $C(0) = a > 0$.
C' F 0 and C" F 0.

The left side of the inequality in equation (3.5) is the expected utility of the buyer if an insurance policy is purchased and the expression on the right is utility if no policy is purchased. The expression on the left side of equation (3.6) is the expected utility of the seller if an insurance policy is sold and the one on the right is utility if a policy is not sold. Both inequalities have to hold if the solution of this system is non-empty. Raviv concludes that an optimal policy will have a deductible if the cost of providing insurance is a function of the type of coverage offered or if the seller is risk averse. If the insurer is not risk neutral or if C" is strictly greater than zero, the optimal policy will have both a deductible and coinsurance.[17]

In the Ahsan, Ali and Kurian model discussed earlier, the conclusion is reached that if there are different risk classes of farmers, an equilibrium in the insurance market will not be attained unless the insurer can distinguish between the different classes perfectly. A corollary to this result is that informational externalities are sufficient to explain the lack of insurance markets in agriculture noted in Chapter 1.

Rothschild and Stiglitz use a graphical analysis to show why an equilibrium might not exist in an insurance market of non-homogeneous buyers. Their basic argument can be illustrated using Figures 3.2 and 3.3. In Figure 3.2, the lines ED and EF represent contract lines, rates at which Y_1 and Y_2 are traded, for high and low risk insurees respectively, that yield zero profit for the seller. The buyers' preferred points are A_h for the high and B for the low risk group. Both points offer the respective consumer full insurance.

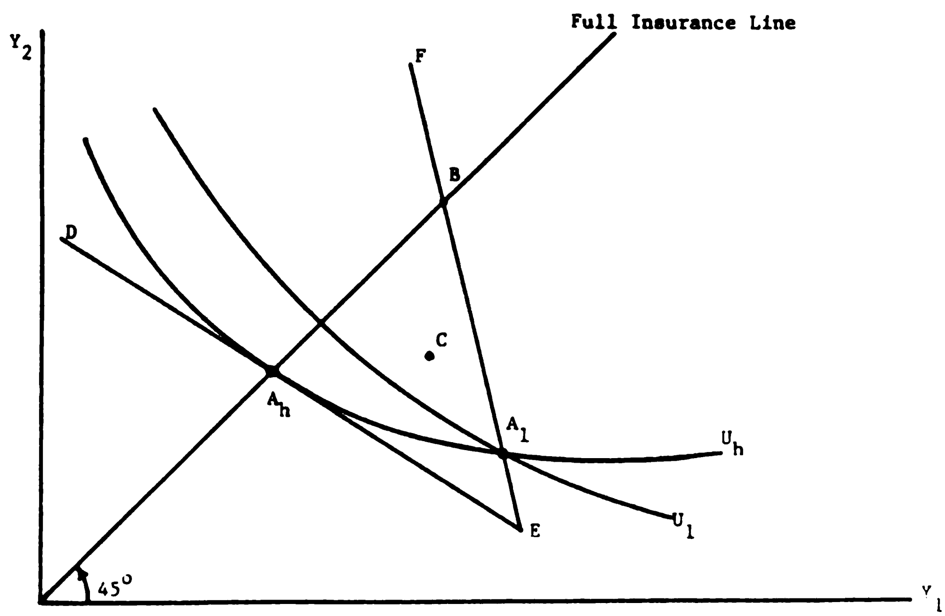

Figure 3.2: Insurance Offerings to Low and High Risk Buyers

Unfortunately, B is not a viable policy unless the seller can discriminate perfectly between the two groups. B is preferred by all high risk buyers, as it would move them to a higher iso-utility curve, and by the low risk group. However, if high risk buyers purchase a contract at B, the insurance company would earn negative profits and would soon be out of business. An insurance policy that would not attract high risk consumers yet leave low risk customers as well off as possible is A_l since this point is on the same iso-utility line and would therefore not induce high risk consumers to move away from A_h which offers them full insurance. However, even the combination (A_l,A_h) may not be an equilibrium. Consider the point c. Both high and low risk customers would prefer c to A_h and A_l since both would move to higher iso-utility curves. The point c might also satisfy the zero profit requirement, depending upon the relative numbers of low and high risk individuals covered by the insurance company.

Rothschild and Stiglitz show that c is not a viable equilibrium point. In Figure 3.3, we assume point c is on the zero profit line. If a different insurance company offers a contract such as m, all low risk consumers will prefer m to c. However, at m the insurer earns a profit because m is below the rate at which low risk buyers must trade Y_2 for Y_1 in an actuarially fair system (the line EF in Figure 3.2). This means the insurer would take in more in favorable states than he disburses in unfavorable ones. Because a profit is earned, the combination (c,m) cannot be an equilibrium. Another firm will offer a plan similar to m but at a lower profit rate. This will continue until the zero profit line is regained. Rothschild and Stiglitz conclude that the only possible equilibrium in a market with two types of buyers is (A_l,A_h) and that even this equilibrium may not exist. This implies that a pooled contract is impossible and separate contracts may not provide an equilibrium either. Specifically, they conclude that if there are only a few high risk consumers or if the cost of separating consumers is high, an equilibrium will not be attained.

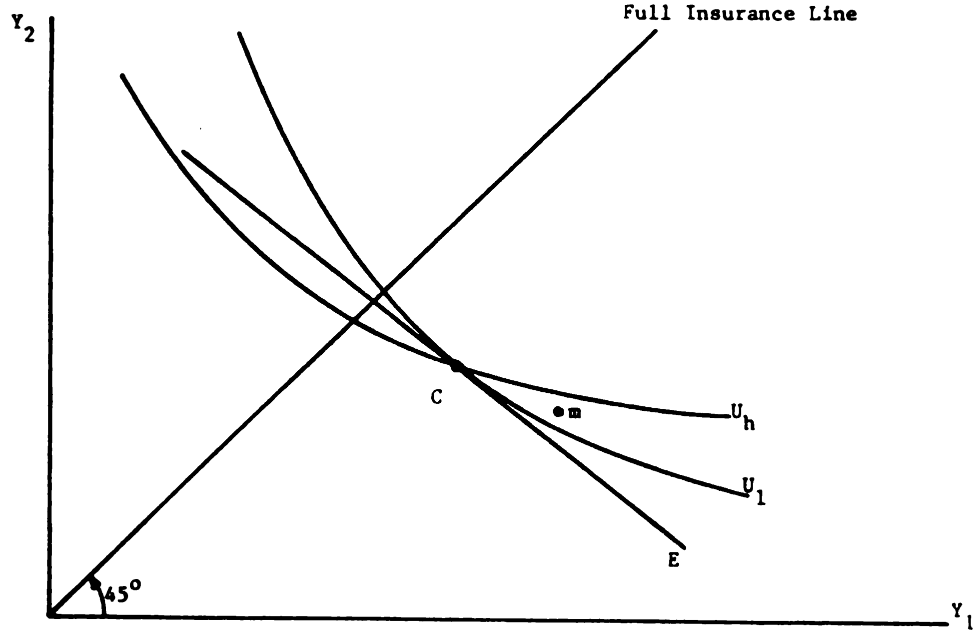

Figure 3.3: Disequilibrium in an Insurance Market with Two Groups of Buyers

Another interesting insight provided by Rothschild and Stiglitz is that the presence of high risk individuals creates a one way externality. The low risk group cannot achieve full insurance yet this does not benefit the high risk group by reducing their premiums or extending their coverage.

Spence and Zeckhauser examine the relationship between full insurance and moral hazard by considering the information an insurance seller can monitor. Their basic model assumes a consumer maximizes the expected value of a von Neumann - Morgenstern utility function subject to a break-even constraint for the seller.[18] The arguments of the utility function and the constraint vary, depending upon the information available to each group. The key components of their model are the sequencing of moves between individuals and the state of nature, and the information state monitored by the insurer. Sequencing refers to when the individual has to choose his desired level of coverage; before or after the state of nature is determined. The information state refers to what the insurer can monitor. The possibilities are the state of nature or the insuree's actions, his expenditures on self protection for instance. The authors conclude that if the insurer can monitor the state of nature directly or individual actions in advance of the state of nature (and alter the insurance pay-off schedule to induce the individual to act in a manner it deems optimal), then full insurance can be provided without causing problems of inappropriate incentives. However, if the insurer can monitor individual actions only after the state of nature is realized, or the effect of the state of nature on the buyer's insured variable, neither complete risk spreading nor appropriate individual incentives will be possible. Again an information cost causes less than optimal performance in the insurance market.

Hogan argues that a way to avoid moral hazard in crop insurance is to make it compulsory. Compulsory crop insurance has the additional advantage that it would allow financial risk to be more equitably distributed by lending institutions. Hogan states that currently, every creditor poses a threat to the economic viability of a bank in that he/she may default on a loan. As a result, every borrower is charged a flat fee, in the form of a higher interest rate, to cover the expenses caused by those who do default. Since each creditor does not pose the same degree of risk, what is needed is a way to allocate the cost of bad debts to those who pose the greatest threat. Compulsory crop insurance is, according to Hogan, such a mechanism. Hogan's assumption is that the price of crop insurance would vary by farmer according to the riskiness of the farm. The insurance contract would be offered as collateral for the loan and the premium paid by the farmer would allocate the financial risk according to the exposure to hazard.

The model developed by Viscusi, summarized in Table 3.1, addresses income and portfolio effects faced by an insurance seller practicing merit pricing. Merit pricing refers to the practice of linking the price of insurance to outcomes in the previous period. Viscusi concluded that because of the inverse relationship between insurance purchases and self protection, merit pricing will have important implications for a seller. Consider a buyer who doesn't have an accident in the first period. If, as a result of his good record, his insurance premium falls in the second period, Viscusi's model predicts he will respond by investing in more self protection and less insurance. The result, for the insurance company is two-fold. First, larger expenditures on self protection would be expected to reduce the amount of benefits the insurance company would have to pay to this buyer. On the other hand, less insurance is purchased by this now-safer consumer which reduces both the importance of this buyer in the company's risk portfolio and the seller's revenue. The net effect on the seller's income is, therefore, ambiguous.

Empirical Models of Insurance Sellers

Explicit empirical models of insurance sellers are few.

However, King's work, cited above, provides useful insights into variables that might be important to insurance sellers. First, King's work indicates that use of a farmer's subjective beliefs about his yield distribution is the best predictor of farmer actions. He derives these yield distributions by means of a series of questions included in a computer simulation. This information could be used to determine premiums and would provide a better loss ratio for the insurer. In his work King estimated minimum and maximum expected loss ratios under a variety of assumptions about program parameters. He found that when using the subjective yield distribution, the minimum loss ratio rose while the maximum fell, relative to the case in which premiums were based on county averages. The reduced maximum expected loss ratio was attributed to reduced problems with adverse selection.

King also suggests the use of the entire historical yield distribution rather than just the mean to determine the terms of the insurance contract. Specifically, inclusion of a measure of the probability of paying an indemnity to a given farmer would improve the performance of the system. This is, in essence empirical confirmation of the phenomenon illustrated in Figure 2.1 on page 27, where the PDFs of Jones and Smith were compared. King's research indicates that greater use of the information contained in a farmer's PDF would increase participation, improve program performance and increase the equity of coverage offered.

THE PSYCHOLOGICAL APPROACH

The analysis of risk and insurance purchase decisions by psychologists tends to be more empirically oriented than the approach favored by economists. Psychologists have been concerned almost exclusively with the behavior of buyers of insurance, not sellers. Based on their empirical work, psychologists have rejected many of the von Neumann - Morgenstern axioms which underlie most economic theories about the behavior of economic agents in risky situations.

In the mid-1950s, Allais identified a condition that has come to be known as the Allais paradox or the certainty effect. Generally, what this says is that decreasing the probability of two events by the same proportion will have a larger impact on the utility associated with what had been a certain event than on an event that was merely highly probable. Tversky and Kahneman present the following example of the Allais paradox. Seventy-seven people were given the following choice:

1. A sure win of $30 or
2. An 80% chance of winning $45.

Seventy-eight percent of the respondents chose the sure thing. In contrast, fifty-eight percent chose to play for the $45 prize in the following game:

3. A 25% chance to win $30 or
4. A 20% chance to win $45.

In the second game both options were reduced by the same factor ,four, vis-a-vis the first set of options.[19] Based on the von Neumann-Morgenstern assumptions, the expectation would be that someone who prefers choice 1 to choice 2 in game one would prefer choice 3 to choice 4 in the second game. The empirical results reported above apparently contradict the axiom of consistency.

Maitel reporting on work done by Tversky offers an example that seems to contradict the axiom of transitivity. Consider the case of a man going to buy a car. Upon arriving at the showroom, he states he wants the basic, no-frills model. He is quoted a price and told that for a few dollars more he can have a model with a radio. For a few dollars more than that, he can have power brakes; for a few dollars above the third price he can get power steering; and so on. At each stage he decides he will purchase the extra equipment. Finally, when the car is loaded with additional equipment he is told that this new car now costs twice what the basic version was going to cost him. At this point he decides to buy the stripped down version.[20] At each stage the buyer preferred the car with the additional piece of equipment yet he preferred the no-frills car to the car with all the extras. The story, while not an actual case, is plausible enough to bring into question the universality of the transitivity property.

Katona believes that at any given time either good or bad news is salient in a person's mind and good or bad news is thought to have only good or bad effects. In addition, he feels that people adopt rules of thumb when facing uncertain choices. Both cases imply that people do not behave rationally in the sense used by economists.

Grether also questions the economists' approach to studying behavior in risky situations. He points to some of the inconsistencies noted above, people's frequent adoption of strategies that seem, to the observer, to be non-optimal and to their substantial and systematic biases in estimating the probabilities of events. He also cites a great deal of evidence showing that people do not use information very

efficiently. In particular, most decision makers do not use Bayes Theorem to revise their probability beliefs.[21]

Tversky and Kahneman used the accumulated empirical information to develop what they have termed "Prospect Theory". In prospect theory the decision maker maximizes an expression of the following general form:

$$\text{Maximize} \quad s_i(p_i)*V(x_i)$$

Where

p_i = Probability of occurrence of event i

$V(x_i)$ = Value of outcome i.

s_i = weight applied to probability p_i.

Furthermore, they hypothesize that the shape of the value function is as shown in Figure 3.4. The shape of V(x) implies that the displeasure

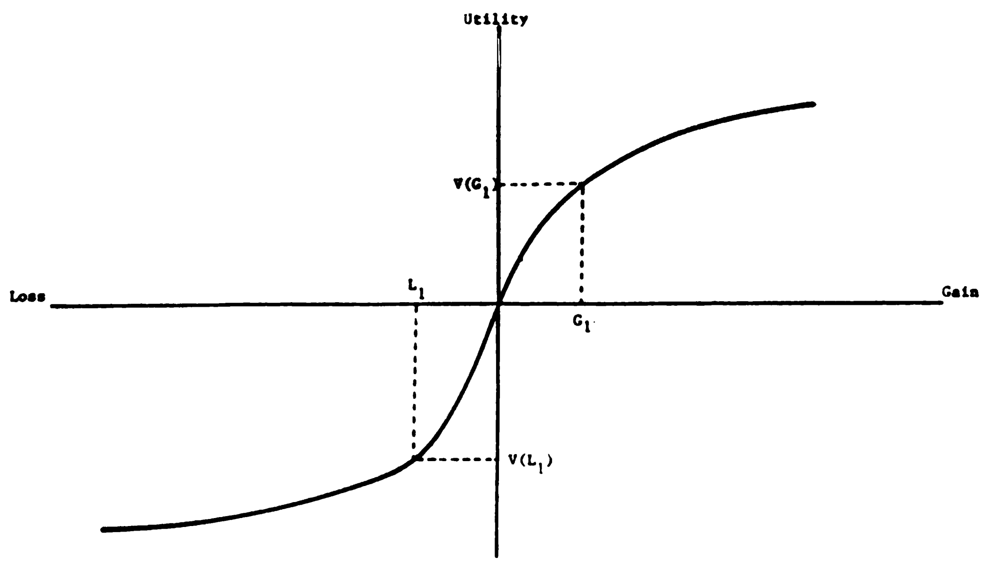

Figure 3.4: The Value Function as Hypothesized by Prospect Theory

associated with a given loss, L_1, is greater than the pleasure of gaining a similar value, G_1, [|V(L1)|>|V(G1)|]. The shape of V(x) and the choice of the (0,0) point, are critical factors in explaining choices under risk. Setting the reference point, (0,0), determines whether a given outcome is considered a gain or a loss. Given the shape of V(x), a shift in the choice of the reference point, or "frame", can alter the preference ordering of an individual.

To conform with empirical findings, Tversky and Kahneman chose a functional form that overweights low probability events and underweights high probability events. They restrict the form of s(p) further by requiring low probability events be overweighted by a smaller proportion than high probability events are underweighted. Finally, they make both s(p) and V(x) non-linear functions. Non-linearity of these functions helps to account for the framing phenomena mentioned above (since the values associated with losses and gains can change in different ways).

Robison (1982) raises questions about prospect theory, not because of its lack of empirical validity, but because s(p) is loosely defined. We do not know how to measure or estimate s(p) nor do we know how it might change across people or time periods. Tversky and Kahneman hold that the function "summarize(s) a common pattern of choice"[22].

Kunreuther and Slovik studied the patterns of home insurance purchases in areas prone to flooding or earthquakes. They found framing to be an important factor. For instance, many people in these areas did not purchase insurance against the specific hazard to which they were exposed because the probability of occurrence in a given year was perceived as small. By changing the frame (lengthening the time horizon and thereby increasing the likelihood that the homeowner would experience the unfavorable outcome in the reference period) many people altered their insurance coverage preferences. Kunreuther and Slovik found that people look upon many forms of insurance as an investment. By lengthening the time horizon, the attractiveness of insurance as an investment was enhanced.

Kunreuther and Slovik also noted the propensity of consumers to insure low cost, high probability events rather than high cost, low probability events. This indicates that the loss of utility associated with a relatively small material loss is more than the small amount of utility gained (saving the premium) by not insuring and hence would seem to conform to Tversky and Kahneman's hypothesis.

A series of recent articles[23] has examined the relationship between risk aversion and the marginal utility of income. In the economics literature, the curvature of an individual's utility function has typically been associated with risk preferences. A utility function defined over income which is concave (convex) is said to indicate risk aversion (loving) in the individual. It has long been recognized, albeit reluctantly, that this curvature contains information about the marginal utility of income for the person in addition to his risk attitudes. Krzysztofowitz states that the utility function for an individual should be written as:

$$U(Y) = W(V(Y)) \tag{3.7}$$

The function U(Y) encodes both attitudes toward risk and strength of preferences while V(Y) measures strength of preference (utility) only and W measures risk attitudes. By a clever structuring of offers, Krzysztofowitz and others feel they can separate the strength of preference component from the risk aversion component. The specific structure of these offers is illustrated in Robison and Fleisher and is summarized below.

Suppose a lottery will pay \$1000 or nothing, with equal likelihood. How much would you pay for a ticket to play this lottery? Let your maximum bid price be \$400. Therefore the utility you get from holding the ticket and the utility associated with \$400 should be equal. This can be expressed as:

$$U(400) = 1/2(U(1000)) + 1/2(U(0)) \qquad (3.8)$$

Suppose you are now asked the maximum amount you would pay to play each of the two lotteries in Table 3.2. Most people will have a clear

Table 2: Two Lotteries

	Lottery a		Lottery b	
	Probability	Payout	Probability	Payout
	1/3	\$1000	2/3	\$400
	2/3	\$0	1/3	\$0

preference for lottery a or b so the maximum bid price for a ticket to play one will exceed the other. However, the following manipulations make clear that the expected utilities are equal. We can easily prove that:

$$1/3(U(1000)) + 2/3(U(0)) = 2/3(U(400)) + 1/3(U(0)) \qquad (3.9)$$

To see that the equality holds, simply substitute the expanded definition of U(400) from equation (3.8) into equation (3.9), multiply and collect terms. The differences in the maximum bid price a person would pay to participate in lottery a or b indicates a preference for or an aversion to chance taking.

To separate risk aversion from changes in marginal utility Krzysztofowicz derives the function V(Y), the pure strength of preference. This is done by first bounding the choice set; 'What is the worst outcome, what is the best outcome?' For example, consider a struggling graduate student for whom the best outcome is a fellowship worth $1000/month and the worst outcome is to remain penniless. We now ask this hapless soul the point at which he is indifferent between moving from $0/month to $X/month and from $X/month to $1000/month. Let's say that for our poor student X is $450; implying that to go from $0/month to $450/month is as satisfying to him as going from $450/month to $1000/month. This process is continued, locating more points of indifference by subdividing the range 0 to 1000 into ever smaller components. A continuous, twice differentiable equation is estimated over the locus of indifference points. The marginal utility of money is said to be increasing, decreasing or constant if m(Y), defined below, is less than, greater than or equal to zero. The quotient m(y)

$$m(Y) = -[(d^2V(Y)/dY^2) \ / \ (dV(Y)/dY)] \qquad (3.10)$$

measures the degree of bending in the strength of preference function. To determine the risk attitudes of an individual, Krzysztofowitz compares the curvature of V(Y) with that of U(Y). The individual will be risk averse (preferring) if U(Y) is more sharply concave (convex) than V(Y). He expresses this property mathematically as:

$$n(Y) = -[(d^2W(V(Y))/d^2V(Y)) \ / \ (dW(V(Y))/dV(Y))] \qquad (3.11)$$

If n(Y) is positive (negative) (zero) the person is relatively risk averse (preferring) (neutral).

The ultimate contribution of this new technique is unclear because it has not received wide-spread empirical testing. At a minimum, it is a creative way of dealing with a problem that has been largely ignored by researchers in the area.

Conclusions

The psychological literature, in general, lacks the rigor of the economists' models. Economists have taken the route of hypothesizing axioms of human behavior that would be observed in a "rational" person. From these axioms, they have constructed some rigorous and elegant models of choice under risk. Psychologists have derived their axioms, not from some preconceived hypotheses of rationality, but from empirical investigations into how people behave. Some of these experiments involve hypothetical situations, some involve actual behavior. Grether holds that the strengths of behavioral axioms derived from experimentation are that they are real, well documented and reproducible. It is important to bear in mind the questions raised earlier by Ehrlich and Becker and by Robison and Lev regarding the inadvisability of inferring risk preferences from observed behavior. In addition, there is no clear route from empirical observations of human behavior in risky situations to a theory. This reduces the generality of the findings of psychologists.

The recent work done by Heiner, Krzysztofowitz and others represents an important step forward, in my view. They are perhaps the beginnings of a bridge connecting the economic and psychological approaches to the study of behavior under risk. It is particularly heartening to note that construction of this bridge is proceeding apace from both sides of the gap that separates the two schools of thought.

The Approach Used in this Study

The approach taken in this thesis is a traditional economic one. The reason for this is not that the misgivings voiced by psychologists have been ignored or downplayed. Rather, the recent work, as represented by Heiner and Krzysztofowitz, has concentrated on microeconomic phenomena while a primary concern of this thesis is at the macroeconomic level. It is unclear how one goes from the micro-level behavioral descriptions of these recent works to macro-economic results.

This thesis will, therefore, use a Mean-Variance model to analyze the revenue insurance program. Details of this approach are provided in the following chapter. The advantages of this approach are an ability to aggregate results and its applicability to a large class of decision makers. We turn now to a more detailed examination of the theoretical models employed in this thesis.

1. See Kunreuther and Slovic, 1978, for a brief discussion of this distinction.

2. This constraint is derived from the expected profit function of the seller:

$$W = (1 - p)aqA - p[aF(A) - aqA]$$

where all variables are as defined in the body of the paper. See Ahsan, Ali and Kurian, 1982, page 522.

3. Full insurance is coverage such that $U'(Y_1) = U'(Y_2)$ implying that $Y_1 = Y_2$ for concave utility functions. The subscripts refer to the state of nature.

4. An actuarially fair price implies an exchange of p/(1 - p) units of income in state 1 for an additional unit of income in state 2, given that state 2 occurs with probability p/(1-p). See Ehrlich and Becker, 1972, page 626.

5. Ehrlich and Becker, op. cit., define insurance as

$$s = I_0 - I_0e$$

Where

s = the amount of insurance purchased.
I_0 = income realized in state 0.
I_0e = endowed or certain income in state 0.

Thus, if p is the price of insurance,

$$ds/dp = dI_0/dp - dI_0e = dI_0/dp$$

since the endowed income will not change with a change in the premium.

6. Ehrlich and Becker, op. cit., page 637.

7. Ehrlich and Becker, op. cit., page 626. They define the cost of self insurance as negative one over the marginal cost of a loss plus one:

$$= -1/(L'(C) + 1)$$

Since they have defined the loss function as the value associated with the favorable state less the value associated with the unfavorable state, the probability of occurrence doesn't affect the cost of self-insurance.

8. Ehrlich and Becker, op. cit., page 637.

9. Viscusi, 1979, page 1205.

10. Viscusi, op. cit., page 1202 and 1205.

11. Adverse selection refers to the situation where only those individuals who know they are likely to collect an indemnity purchase insurance. In short, only high risk people buy protection.

12. Moral hazard is the case in which the purchaser of insurance has an incentive to allow the unfavorable event to occur.

13. Heiner, 1983, page 561.

14. Heiner, op.cit., page 569.

15. Heiner, op. cit., page 577.

16. King and Oamek, 1983, page 18.

17. Coinsurance means that for losses above a given level, the insurer and insured share losses according to some schedule.

18. von Neumann and Morgenstern, 1947, define rationality in a consumer by postulating conformance to six axioms:

Orderability	- consumers can rank the prferability of all choices available.
Transitivity	- if option a is preferred to option b and option b is preferred to option c, then a will be preferred to c.
Continuity	- by altering the probabilities attached to outcomes, indifference between any two outcomes can be achieved.
Substitutability	- if a consumer is indifferent between apples and oranges and the only difference between two fruit salads is that one has apples and the other oranges, he will be indifferent between the two salads.
Monotonicity	- increasing the probability of a favorable event increases the utility of the decision maker.
Probability	- it is assumed that consumers accurately and correctly use statistical data.

19. Tversky and Kahneman, 1981, page 455.

20. Maitel, page 197.

21. Bayes Theorem is used to calculate conditional probabilities. A conditional probability calculates the likelihood of an event occurring given that we have information about which of numerous possible states of nature will occur. It is used to revise beliefs about the environment a decision maker faces.

22. Tversky and Kahneman, op. cit., page 454.

23. See Krzysztofowitz 1983, and Bell and Raiffa, 1979, as examples of this literature.

Chapter 4

A Theoretical Model of Revenue Insurance Demand

This chapter describes the expected value-variance (E-V) model and presents a graphical description of the revenue insurance program. Then, using the E-V model, a mathematical model of insurance demand is developed and interpreted.

An Expected Value-Variance Model

A E-V model describes action choices, or options available to a decision maker, in terms of their expected values (μ) and variances . From the set of action choices available to the decision maker, the expected value-variance (EV) frontier is formed. To be a member of the EV frontier, the choice must have a smaller variance (expected value) than all other options with the same expected value (variance). Only points on the frontier are considered by a decision maker. Figure 4.1 illustrates an EV frontier. Action choices located in the lower left-hand portion of the quadrant are low mean, low variance outcomes. In order to achieve a higher mean outcome, the decision-maker must be willing to accept greater variability. Moving to the right along the EV frontier, the trade-off between μ and σ^2 is progressively less favorable in the sense that increasing amounts of variability must be accepted for each additional unit increase in

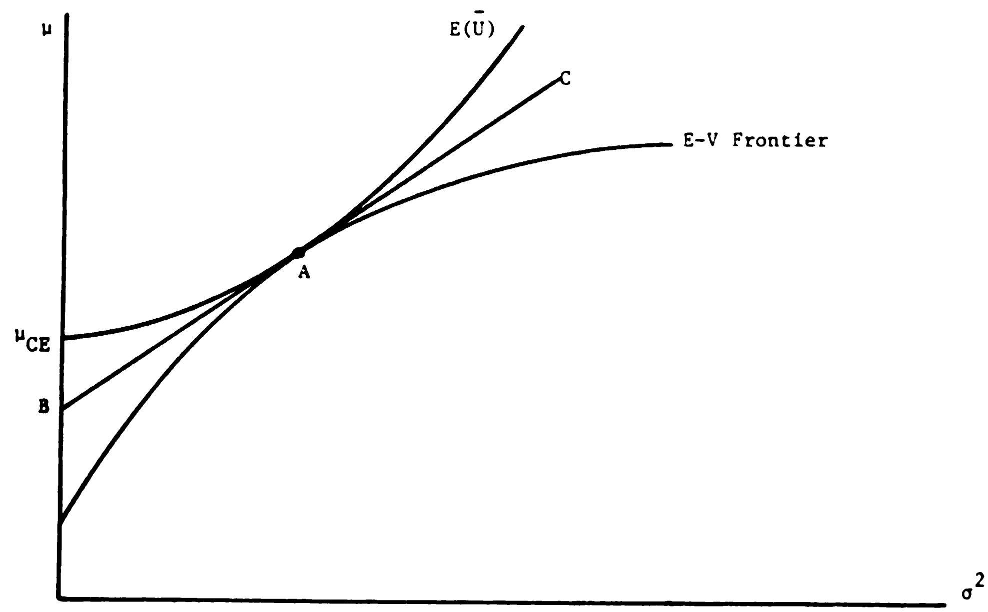

Figure 4.1: Equilibrium on an EV Frontier

the mean outcome. What is required for an optimum in EV space is tangency between an isoexpected utility curve, (E(Ū)), for the decision maker and the EV Frontier. In Figure 4.1 this equilibrium is shown as point A. The intercept, μ_{CE} is the certainty equivalent level of income, the level received with certainty that leaves the decision maker as well off as all other points on E(Ū). The curve E(Ū) is not observable and is difficult to derive.[1] Therefore, the line BC might be used as a linear approximation of the isoexpected utility curve. By requiring the line be tangent to the EV frontier at A, the same solution is obtained from our linear approximation as from the curve E(Ū). The point B is the intercept of the linear tangent and approximates the certainty equivalent (μ_{CE}) level of income. Since we are in expected value-variance space, the formula for BC will be of the general form:

$$\mu = CE + \alpha\sigma^2 \qquad (4.1)$$

Where α is some constant and CE is the certainty equivalent level of income for the linear tangent. Fruend has shown that α is equal to $\lambda(\mu)/2$, a linear approximation of the Pratt-Arrow absolute risk aversion coefficient.[2] Therefore, if we can map the EV set and observe the equilibrium point chosen by the decision maker, we can express the approximation of the isoexpected utility curve, after rearranging terms, as:

$$CE = \mu - (\lambda/2)\sigma^2 \qquad (4.2)$$

We will call equation (4.2) the Certainty Equivalent expression. Knowledge of the specific form of the decision maker's utility function is not needed for this approximation.

Use of the certainty equivalent expression to analyze a decision maker's optimal choice was thought to be restricted to cases in which the decision maker's utility function was quadratic or when the probability density functions (PDF) of the available action choices were fully described by their means and variances. Neither of these conditions is likely to hold in agriculture, yet the approach used is justifiable because the error associated with EV set analysis will be small if the distributions being considered are not highly skewed. Furthermore, it has been shown both theoretically and empirically that the EV set closely approximates the efficient set produced by second degree stochastic dominance. What this means is that for all decision makers whose utility functions are concave downward [U'> 0, U"< 0] the EV set will contain the preferred action choice.

In addition, much of the criticism of E-V models has been based on the fact that they are not consistent with Expected Utility (EU) models. Given the criticisms of the EU models discussed in the preceding chapter, it may not be appropriate to reject use of the E-V model simply because it does not, in all cases, conform to a model that many don't believe in the first place. As Meyer and Robison say, "if a valuation function can be deduced which orders action choices over means and variances in a manner consistent with our intuition and experience, its usefulness should not be questioned simply because it lacks consistency with EU models."[3] Meyer and Robison deduce a case in which there is always consistency between the E-V and EU models. If there is but one risky asset in the decision maker's portfolio and we require the slope of the line BC in Figure 4.1 to increase, (remain constant), (decrease) as the decision maker exhibits increasing, (constant), (decreasing), absolute risk aversion, the E-V and EU model results will always be consistent. This result derives from the fact that with only one risky option, the EV frontier is composed of various combinations of risky and safe assets. This means that the choice which maximizes the EU model will, by definition, be a member of the EV set.

A Conceptual View of the Insurance Option

Virtually all risk-reducing strategies work on the principle of trying to modify a probability density function (PDF) of concern to the decision maker. Insurance offers three basic types of modifications. The deductible form of insurance, common in automobile insurance policies, takes the probability of events worse than the insured level and "piles" it at that level. In addition, the entire distribution is shifted to the left by the amount of the premium paid for coverage. This is shown in Figure 4.2. When facing a distribution of output such as Figure 4.2, the decision maker with a deductible insurance policy is assured of an outcome of at least x_1. Should an outcome such as x_2 occur, the insurer pays the insured an amount (x_1 - x_2).

A second type of modification offered by insurance is termed coinsurance. With coinsurance the insured and insurer share the cost of unfavorable outcomes. If the purchaser has a coinsurance provision

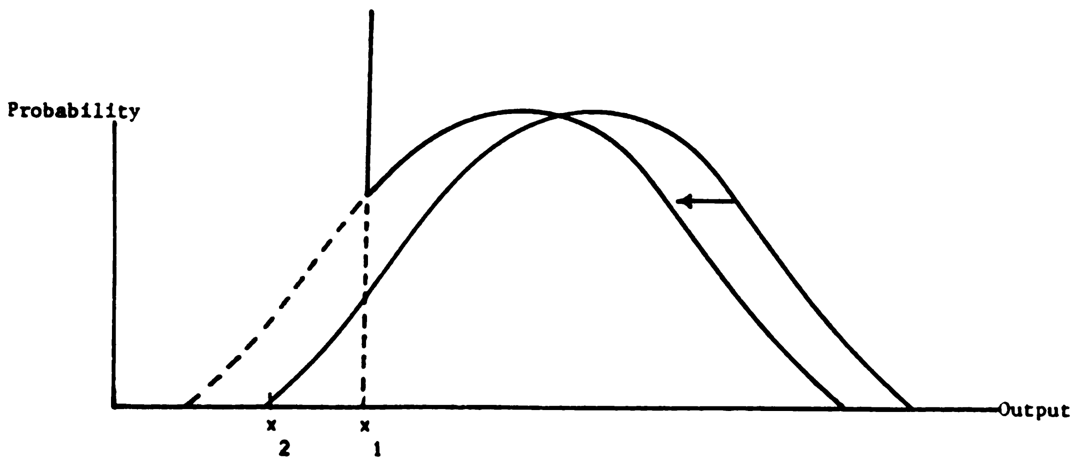

Figure 4.2: The PDF with a Deductible Form of Insurance

whereby she is liable for 25 percent of the value of lost output and the insurer covers the other 75 percent, a loss of $200.00 means the insurance company will pay her $150.00 and she will be responsible for the remaining $50.00. Again, the entire distribution is shifted to the right by the amount of the premium. See Figure 4.3 for an illustration of how coinsurance changes the distribution.

The third form is a hybrid of the deductible and coinsurance forms. A policy with coinsurance above a specified deductible is frequently used in medical insurance policies.

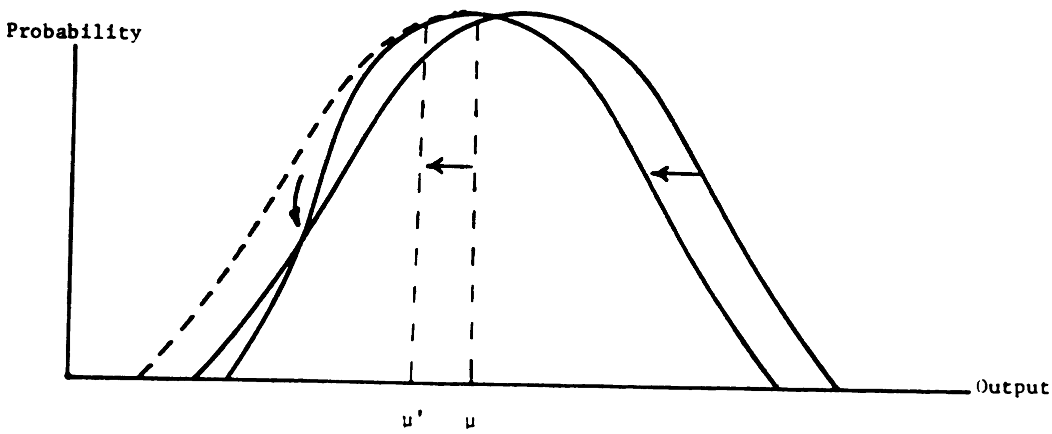

Figure 4.3: The PDF with the Coinsurance Form of Insurance

Revenue insurance, as currently discussed, would be a deductible type of insurance. It would be similar in form to the current crop insurance program in that a fixed deductible, say $200, will be replaced by a deductible that is a function of the mean level of revenue over some historical time period. We will call the deductible level in a revenue insurance policy the coverage ratio. Suppose the average revenue over the past few years for farmer Jones is $100,000 per year. With revenue insurance he could insure that his gross revenue from farming will not fall below some proportion of this amount, say $75,000, in the comming year. In exchange, Jones pays a premium, π . Figure 4.4 illustrates how a revenue insurance program would modify Jones' PDF over revenue.

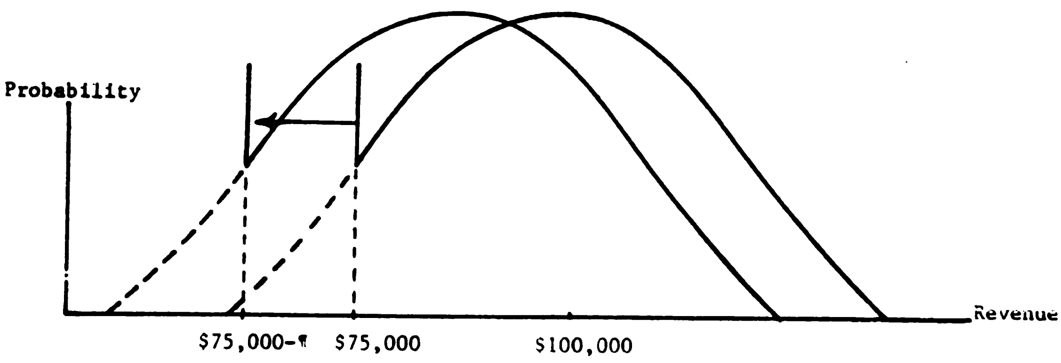

Figure 4.4: The Effect of Revenue Insurance for Farmer Jones

Purchase of the revenue insurance policy truncates the revenue distribution at $a\mu$. In the Jones case, the mean, μ, is $100,000 and the coverage ratio, a, is .75. The entire PDF is shifted to the left by the amount of the premium, π. All of the probability that had been in the left-hand tail of the original PDF is accumulated at the deductible level, $75,000. The mean of the truncated distribution will be somewhere to the left of the old mean. If the mean of the post insurance distribution remained the same (increased), the buyer would receive as much (more) in benefits from the insurance policy as he pays in premiums. While this may be the case for an individual in a given time period, it cannot be true for the aggregate of individuals across time periods. If it was true, the insurance company would lose money and eventually go out of business. Insurance will be expected to decrease the variance of outcomes.

A Mathematical Model of Insurance Demand

To model a decision maker's response to revenue insurance by means of E-V model, expressions for the mean (I*) and variance (σ^{*2}) of the truncated distribution are needed. Since the pre-insurance mean and variance are known, the post-insurance PDF should be defined in terms of these values. The new mean may be defined as:

$$I^* = (a\mu - C - \pi)\int_0^{a\mu} f(Y)dY + \int_{a\mu}^{+\infty} (Y - C - \pi)f(Y)dY \qquad (4.3)$$

In equation (4.3), π is the insurance premium, C is the farmer's non-insurance costs and f(Y) is the probability density function over revenue. All other variables are as previously defined. It should be pointed out that equation (4.3) is in terms of income, not revenue. The intuitive reason for this is the belief that farmers will evaluate the revenue insurance program in terms of what it will do for their net income position. In addition, the E-V Model contains the buyer's risk aversion coefficient. Since this variable is defined over income, the other terms in the expression also need to be in terms of income to remain consistent.

Equation (4.3) may be interpreted as follows. The first term to the right of the equality calculates the probability weighted value of receiving the deductible level of income. The probability of an indemnifiable event is multiplied by the minimum revenue the purchaser will receive, $a\mu$, less the premium and non-insurance costs. In the second portion of the equation the mean outcome over the portion of the PDF not covered by insurance is calculated and costs and premiums are again deducted.

To simplify the expression in (4.3), define the following:

$$P = \int_{0}^{a\mu} f(Y)dY$$

and

$$E(Y_2) = Y_2 = \int_{a\mu}^{+\infty} Yf(Y)dY$$

The term P is simply the cumulative probability at $a\mu$ and Y_2 is the mean outcome above the point of truncation. Using these definitions, Equation (4.3) becomes:

$$I* = a\mu P + Y_2 - \pi - C \qquad (4.4)$$

To form the variance for the post insurance distribution, recall that the variance of a linear combination of a variable x which is of the general form $\alpha_0 + \alpha_1 x$, is simply α^2 times the variance of x. All constant terms which do not multiply Y in equation (4.1) can, therefore, be ignored when forming the variance of the truncated distribution.

Define a new variable Z with the following distribution:

$$Z = \begin{cases} a\mu \text{ with probability } P \\ Y \text{ with probability } f(Y) \end{cases}$$

Therefore, the expectation of Z is:

$$E(Z) = a\mu + Y_2$$

So the variance of Z is:

$$\sigma^2_Z = (a\mu)^2 P + \int_{a\mu}^{+\infty} Y^2 f(Y)dY - (a\mu P + Y_2)^2$$

$$= (a\mu)^2P(1 - P) + (1 - P)\mu^2 + \sigma_2^2 - 2a\mu Y_2 P - Y_2^2 \qquad (4.5)$$

Where

$$\sigma_2^2 = \int_{a\mu}^{+\infty} Y^2 f(Y)dY - (1 - P)\mu^2$$

In this model the insurance premium is based on the average indemnity paid by the insurance company. The average indemnity may be defined as:

$$\bar{i} = \int_{0}^{a\mu} (a\mu - Y)f(Y)dY$$

$$= a\mu P - Y_1$$

The premium paid by a buyer will be defined as:

$$\pi = \psi(a\mu P - Y_1)$$

Where

$$\psi > 1$$

This simply says that the insurance company will charge the average indemnity plus some percentage for the coverage it extends. The amount by which ψ exceeds 1 will be referred to as the loading factor. The loading factor is designed to cover the insurance company's fixed and variable costs. With this definition of π, the buyer's insured mean income can be rewritten as:

$$I* = a\mu P + Y_2 - \psi(a\mu P - Y_1) - C \qquad (4.6)$$

Since the premium doesn't appear in the buyer's variance expression, its definition doesn't change. Table 4.1 summarizes the properties of I^* and σ^{*2} with respect to the parameters in the model. Table 4.1 indicates that an increase in the coverage ratio, the loading factor, the pre-insurance mean or other farm costs cause the mean of the post-insurance income distribution to fall. The only unambiguous signs for the variance term are with respect to the coverage level and the mean outcome. An increase in the coverage level or the mean reduces the variance. Intuitive explanations of the ambiguous signs will be provided as part of the discussion of the E-V model. The mathematical expressions from which these results are derived in Appendix 1.

Table 4.1: The Effect of Changes in Model Variables on the Mean and Variance of a Farmer's Insured Revenue PDF.

Exogenous Variable	Sign of I^*	Sign of σ^{*2}
a	-	-
φ	-	(b)
C	-	(b)
μ	-	-
Y	?(c)	?
2		

a. Assuming a risk averse decision maker.
b. Terms do not appear in the definition.
c. ? = ambiguous.

Forming the Certainty Equivalent Expression

The expressions (4.6) and (4.5) are used to form the certainty equivalent expression for an insurance buyer:

$$CE = a\mu P + Y_2 - \psi(a\mu P - Y_1) - C - (\lambda/2)[\sigma^2_2 + (a\mu)^2(P(1 - P)) - 2a\mu Y_2 P + \mu^2(1 - P) - Y^2_2] \qquad (4.7)$$

Having formed the certainty equivalent expression, what is the optimal level of insurance to carry? Differentiating (4.7) with respect to "a" and setting the resulting expression equal to zero, the optimal insurance coverage is:

$$dCE/da = \mu P(1 - \psi \; - \lambda[a\mu(1 - P) - Y_2]) = 0 \qquad (4.8)$$

So, at the optimal level of insurance,

$$0 = 1 - \psi \; - \lambda[a\mu(1 - P) - Y] \qquad (4.9)$$

Since the coverage level, a, is part of the definition for P and Y_2, it is difficult to solve for a*, the optimal coverage ratio. It is, however, possible to solve for the optimal loading factor, a fact used in the empirical portion of this study. Furthermore, the expression in equation (4.9) can be used to determine how the coverage ratio will change in response to changes in other model parameters by implicit differentiation. For example, suppose there is an increase in the loading factor, what will happen to the optimal coverage level? To determine this, equation (4.9) is totally differentiated with respect to a and ψ to get:

$$d^2CE = [-\lambda(\mu(1 - P))]da - [1]d\psi = 0 \tag{4.10}$$

or

$$(da/d\psi) = 1/(-\lambda\mu(1-P)) < 0$$

This result simply says that as the loading factor increases, the optimal level of coverage will fall. Table 4.2 summarizes the relationship between the optimal coverage ratio and the exogenous factors in equation (4.9). The results indicate that as a person becomes more risk averse, the insurance coverage sought will increase. If the mean of the farmer's revenue PDF increases and the farmer is decreasingly risk averse or risk neutral, the optimal coverage ratio will fall. Decreasing risk aversion implies that as wealth increases so does willingness to bear risk. This condition is expected to hold for most people. The young person who has just graduated from university is probably less willing to accept a fair bet of $100 than he will be when he becomes the chief executive officer of a Fortune 500 company.

Finally, the ambiguity of a change in Y_2 (and Y_1 or P as well) on the amount of insurance coverage sought can be explained intuitively. Two cases will be discussed below. In both cases, the mean of the pre-insurance distribution is held constant. This allows us to concentrate on substitution effects. If decreasing or constant risk aversion is assumed, the analysis that follows will not change even if income effects are included.

Table 4.2: The Impact on the Optimal Level of Insurance of Changes in the Factors Y_2, μ, λ, ψ.

Exogenous Factor	Sign of a*
Y_2	?
λ	+
μ	?(1)
ψ	-

1. If the buyer exhibits constant or decreasing risk aversion, this sign will be negative.

Consider how an increase in the mean outcome above the truncation level, Y_2 , affects demand for insurance. Two scenarios are possible for this mean preserving spread. An increase in Y_2 could be achieved holding P constant. This scenario implies that probability may be shifted within the two parts of the distribution (the insured and uninsured portions) but not between the two parts. This type of change is depicted in Figure 4.5. In Figure 4.5 the α are all equal indicating that the mean has not changed but a given amount of probability has been taken from a region nearer the mean and moved further into the tails. Another result of this change is a shift from Y_2 (Y_1) to Y_2' (Y_1') as illustrated in Figure 4.5. As an example of this type of shift, consider the following. Suppose trading relationships between two countries have been disrupted. The buying country becomes erratic in its importation policies. Sometimes it comes into the market in a big way, buys large quantities of agricultural products and thereby creates a tight market in the supplier country. Prices and revenues for farmers in the supplier country rise. Just as frequently, however, the importing country buys little, surplus stocks develop and prices and revenues fall.

What is the effect of this sort of change on the demand for insurance? The model predicts demand will increase. The average indemnity received increases in this situation, making insurance a better buy. The environment facing the decision maker is riskier, in the Rothschild and Stiglitz sense. This being the case, demand for insurance should increase.

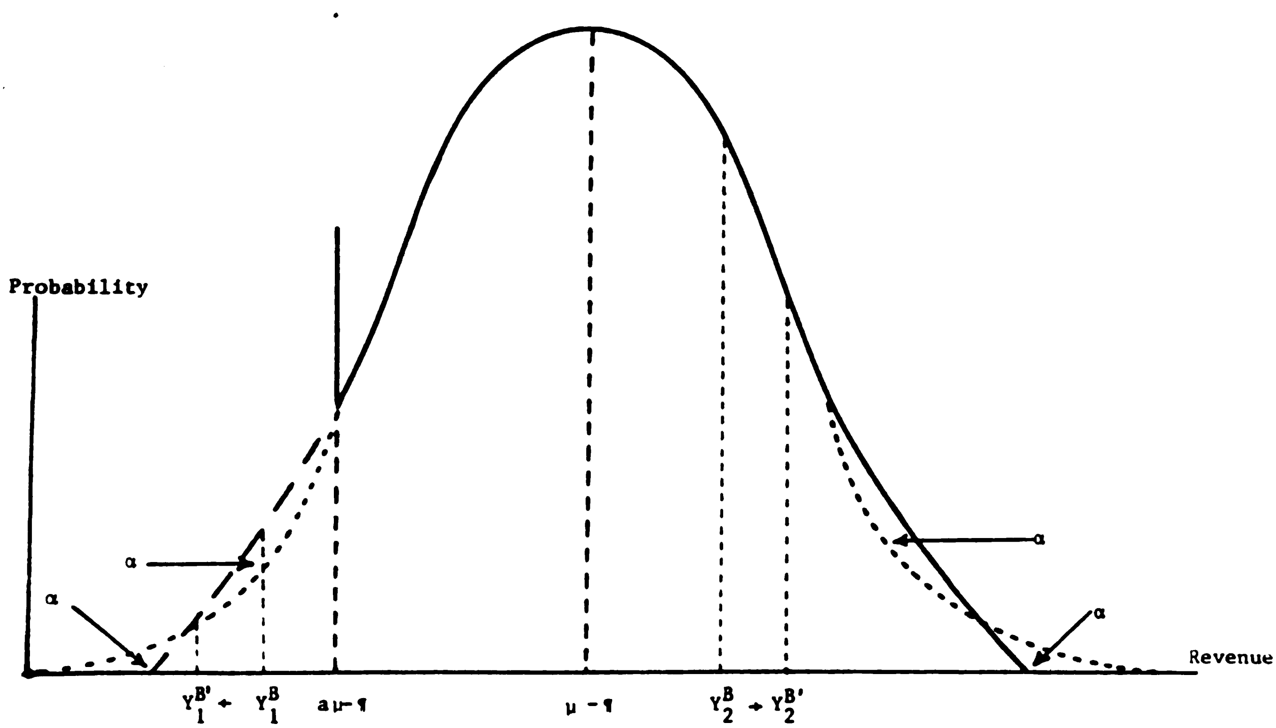

Figure 4.5: A Mean Preserving Spread Holding P Constant

In the second case, Y_2 increases but P is no longer constant. If P increases to P' as shown in Figure 4.6, demand for insurance should increase since an increase in Y_2 , holding constant, implies a fall in the average outcome over the insured portion of the distribution to Y_1'. This means the average indemnity received increases. Since the average indemnity is larger and the probability of receiving it has increased, demand for insurance should rise. Such a change might result from weather patterns that become more variable. Another explanation might be the existence of moral hazard. Suppose for example, a farmer sees that his crop is doing poorly because of weeds or insect damage. He might find it economically advantageous to forego the expense of applying herbicides or pesticides and collect on his insurance policy instead.

It is also possible that P decreases while Y_2 increases. This sort of change will have an ambiguous effect on demand. While the average indemnity will still increase, since Y_1 falls, the probability of receiving a payment decreases. Figure 4.7 illustrates this scenario. A situation causing this type of shift might be a change from a highly specialized farm to greater diversification. With greater diversification, more probability will be stacked in the central portions of the PDF since to be in either tail, revenues from all sources have to fall or rise simultaneously. By implication, less probability is left in the tails since it is less likely that

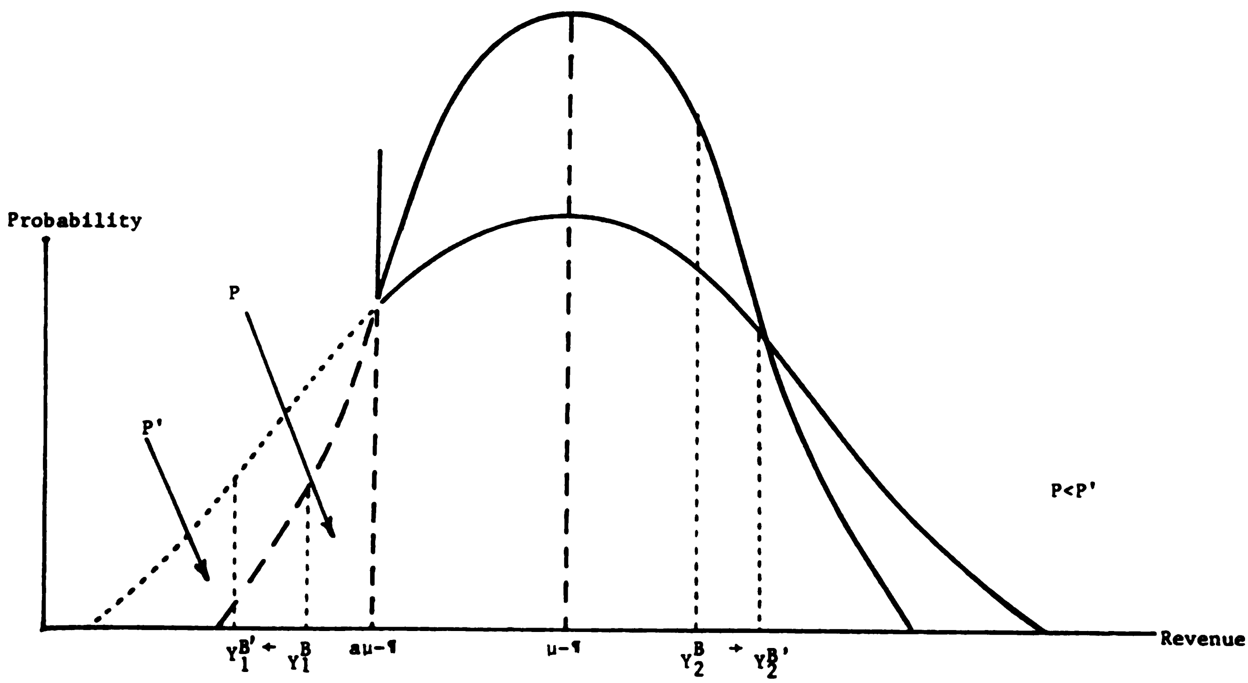

Figure 4.6: A Mean Preserving Spread, P and Y_2 Increase.

revenues from all crops would be perfectly correlated. However, if all revenue sources on a diversified farm do experience low revenues in a given year, revenues might be expected to fall vis-a-vis the specialized farm which is taking advantage of economies of size more completely. As argued above, it is unclear how diversification would affect demand for insurance because of the countervailing impacts of a higher average indemnity coupled with a lower probability of a pay-out.

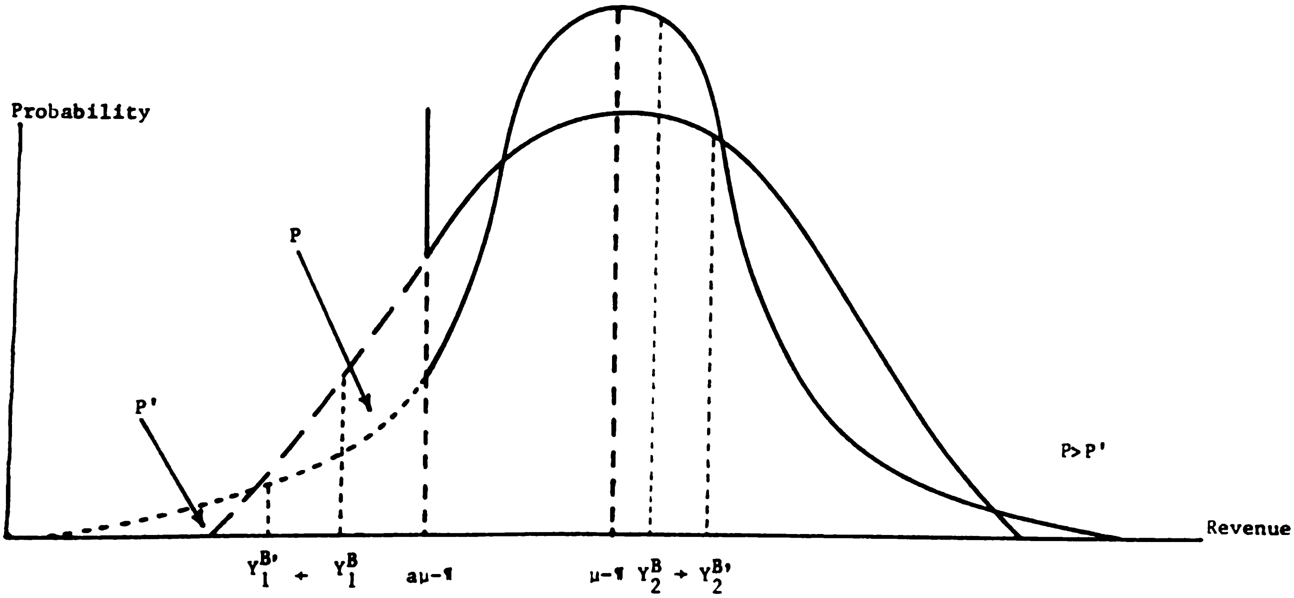

FIGURE 4.7: A Mean Preserving Spread, P Decreases and Y_2 Increases.

Because of their interrelationships, similar arguments hold for changes in P or Y_1. The conclusion is the impact on demand for insurance caused by changes in P, (1 - P), Y_1 or Y_2 cannot be predicted without knowing the nature of the changes involved.

The mathematical expressions for the relationships between changes in model parameters and optimal insurance coverage are provided in Appendix 2.

Conclusion

This chapter has derived the demand for revenue insurance in the context of a E-V model. While most of the model results conform to intuitive expectations others were more surprising. In particular, it was discovered that the effect of a mean preserving shift that changes Y_1, Y_2, or P is ambiguous. At a minimum, the specific type of shift involved must be known in order to predict the impact on insurance demand. In some cases knowledge of the characteristics of the shift will not be sufficient to allow us to predict the direction of change unambiguously.

A number of interesting policy implications can be drawn from the results of this model. First, as expected, an increase in the loading factor charged will be likely to cause a farmer to decrease the level of insurance coverage he purchases. The loading factor might be increased if the nonindemnity costs of the revenue insurance program increased. The inclination of the insurer would be to increase the amount he charges if his own cost of doing business increases. If the negative relationship between the coverage level and the loading factor is sufficiently strong the economic position of the firm could deteriorate if the loading factor is increased. Furthermore, there is the additional consideration of portfolio effects to consider. An increase in the loading factor could drive those buyers who pose the least threat to the economic viability of the insurer out of the insurance market.

It was also shown that an increase in the buyer's risk aversion coefficient would be expected to increase the coverage demanded. An increase in the risk aversion of a buyer could be caused by a number of factors: a revision of his subjective beliefs about the revenue PDF he faces, a deterioration of his equity position, and so on. For example, a farmer in the U.S. Corn Belt may, as a result of last year's drought, believe weather patterns are going to be unfavorable over the next few years. This may lead him to increase the the level of insurance protection sought. Because he believes the riskiness of the environment has increased, this farmer would like to allocate more of the risk bearing responsibilities to the insurance company.

Another interesting conclusion growing out of the theoretical model is that with decreasing or constant risk aversion an increase in the mean of the pre-insurance revenue PDF will, ceteris paribus, cause the coverage level sought to fall. In practical terms this implies that an increase in the wealth of a farmer will reduce the insurance coverage sought. Since younger farmers are likely to have less wealth, the expectation would be that younger farmers would be more attracted to this program than older, wealthier farmers. If revenue insurance increases the ability of a farm to weather a bad year or two, this higher level of demand from younger, poorer farmers could have important implications for the structure of farming.

Finally, the rather extensive discussion of how a change in Y_1, Y_2, or P might affect demand for revenue insurance highlights the importance of changes in the characteristics of the revenue PDF on demand for insurance. Many of the changes discussed could result from changes in government policies (ie. trade policy) or individual incentives (ie. moral hazard). These results indicate that the success or failure of a revenue insurance program depends heavily upon a variety of human actions, not all of which are directly dependent upon the revenue insurance program per se.

Having gained a greater appreciation of the complexity of insurance demand, it is now time to turn to an examination of insurance supply. It is on the supply side of the market that many of the more pressing questions about revenue insurance are found.

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1. See Tversky and Kahneman, 1981, for a discussion of some of the difficulties encountered when trying to derive the utility function of an individual facing uncertain action choices.

2. See Pratt for a discussion of the absolute risk coefficient, defined as

$$R(\mu) = -U''(\mu)/U'(\mu)$$

$R(\mu)$ is a measure of a decision maker's aversion to risk. A positive value for $R(\mu)$ indicates risk aversion. The attraction of $R(\mu)$ is that it is a unique measure of a decision maker's risk preferences. This has distinct advantages over the use of an estimated utility function to determine the decision maker's risk preferences since an estimated utility function will provide a unique and consistent ordering of preferences up to a positive linear transformation only. Using $R(\mu)$ allows transformation of the estimated utility function in any fashion and still obtain the same ordering of preferences.

3. Meyer J. and Lindon J. Robison, 1984, page 3.

Chapter 5

A Theoretical Model of Insurance Supply

Insurance works because the insurance seller can pool the risks faced by a large number of people and take advantage of experiences that are not perfectly positively correlated. Less than perfect positive correlation means there will be occasions when the seller does not have to pay indemnities to all his clients. The insurance company uses the premiums from buyers who did not suffer an indemnifiable loss to off-set the benefits it extends to buyers who did. For this reason, a model of insurance supply must include multiple buyers. In this chapter the E-V model developed in Chapter 4 will be extended to include multiple buyers and one seller. The results of this aggregate model will provide the basis for predictions about the macroeconomic impacts of a revenue insurance program.

The Supply of Insurance

Three factors determine the workability of insurance. The three, discussed earlier, were (1) the extent to which hazards are correlated, (2) the number of participants in the insurance pool and (3) the quality of the data. A measure of the extent to which hazards are correlated is included in the supply model by means of the correlation coefficient. The seller would like the correlation coefficient to be strongly negative. If it is, the probability that its clients will simultaneously experience outcomes that make the insurer liable for payouts will be low.

Correlation, of course, requires more than one buyer, In addition, the underlying principle of insurance is that pooling risks enables individuals to achieve protection from catastrophic outcomes for less than it would cost them to self-insure. This is possible only when a large number of buyers with uncorrelated hazards purchase insurance.

The issue of data quality is tremendously important for the design of an actuarilly sound revenue insurance program. Unfortunately, it is not an issue the models to be built will be able to consider, at least directly. The data issue will be discussed more extensively in Chapter 6, where the empirical portion of this investigation is described and discussed.

A Market Model of Revenue Insurance

The seller's costs and returns are, in essence, the opposite of the buyer's. For a buyer, the purchase of insurance means he is no longer as concerned about outcomes below his deductible level since he will, after receiving his indemnity, always get $a\mu$ dollars. The seller, on the other hand, is concerned with precisely this region. Figure 5.1 illustrates the revenue expectations for the insurance seller. Below the deductible level for a given buyer, the seller earns the premium less the indemnity paid to the buyer. Above the deductible level the seller earns the premium. Costs other than indemnities have to be paid regardless of the client's experiences so the entire distribution is shifted to the left by B. These nonindemnity costs are assumed to be constant.

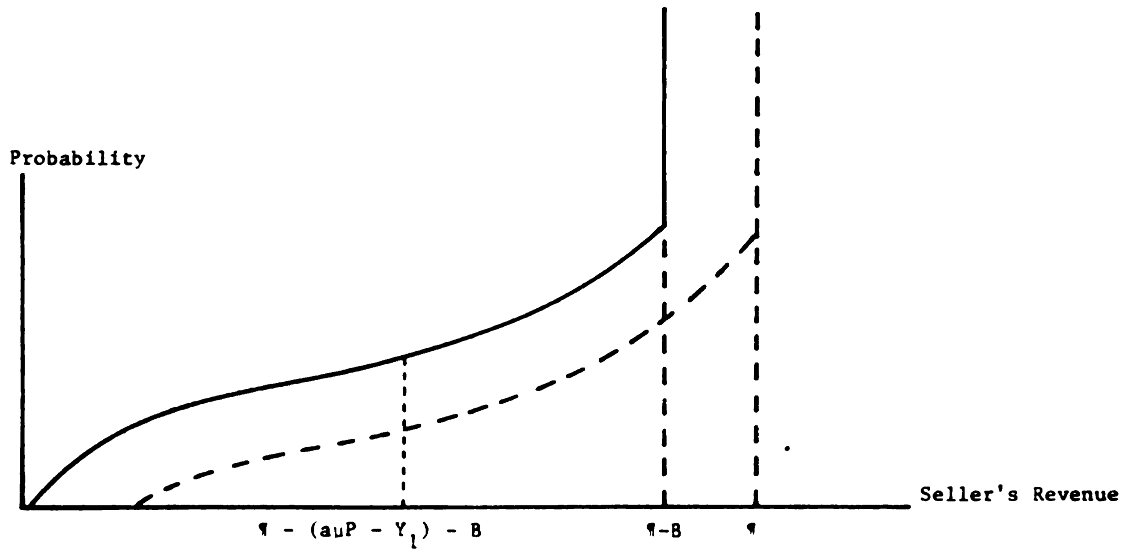

Figure 5.1: PDF of Seller's Revenue from a Given Buyer

Figure 5.1 illustrates the seller's revenue experience with one buyer. Each of its n clients, where n is some large number, will generate its own unique revenue history for the seller. We can picture a series of figures such as the one portrayed in Figure 5.1 with some PDFs stretched and others contracted. Figure 5.2 depicts three such PDFs.

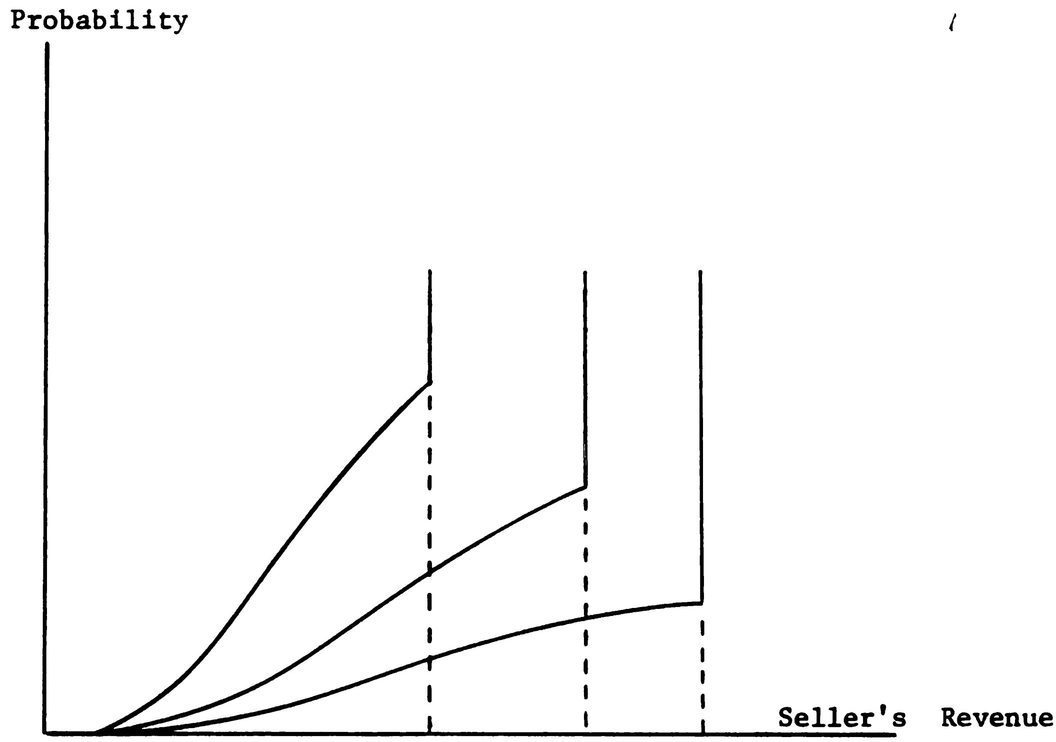

Figure 5.2: The PDF of Returns to the Seller from Three Buyers

The seller's total return in any given period will be the sum of the premiums collected from its n clients less the payments made to the subset of buyers who experience indemnifiable losses less the non-indemnity costs. Since neither the number of clients to whom benefits will be paid, nor the size of these benefits is fixed, the seller's return in a given period cannot be known with certainty. Over time and with a large enough pool of buyers, however, both of these variables can be predicted with a high degree of accuracy if the conditions producing the PDFs pictured in Figure 5.2 are stable or change slowly. It is the stability of these relationships that allows an insurance company to develop the actuarial tables that predict the likelihood of hail devastating the corn crop on a farm in Huron County, Michigan or of an American male, sixteen years of age, having an accident in his sportscar.

The returns to the seller will vary from period to period. The amount of variability experienced by the seller will be a function of the variability experienced by its clients and the extent to which this variability is correlated across buyers.

In the next section mathematical expressions are developed for the seller's expected returns and the variance of returns.

A Mathematical Model of Insurance Supply

The expected revenue of a seller with n buyers can be expressed as:

$$E(R^S) = (\sum_{i=1}^{n} \pi_i - (a_i \mu_i P_i - Y_{i1})) - B \tag{5.1}$$

$$= (\sum_{i=1}^{n} (\psi_i - 1)(a_i \mu_i P_i - Y_{i1})) - B \tag{5.2}$$

Where:

π_i = Premium for buyer i.

ψ_i = The loading factor for buyer i.

a_i = Coverage ratio chosen by buyer i.

μ_i = Mean outcome for buyer i.

P_i = Probability in the insured portion of buyer i's revenue PDF.

Y_{1i} = Average outcome of buyer i over the insured portion of the PDF.

B = Fixed costs.

Equations (5.1) and (5.2) describe mathematically the expected revenue of the seller that was described in prose in the previous section. Equation (5.1) indicates that the seller's expected net returns will be the premium charged less the average indemnity for each of its n clients, less non-indemnity costs. Equation (5.2) uses the definition for the premium developed in Chapter 4, $\psi_i(a_i \mu_i P_i - Y_{i1})$, to simplify the expression for expected returns. The subscripts in the equations refer to the individual buyers in the insurance pool.

Because the very general form of the model described in equation (5.1) is not mathematically tractable, several simplifying assumptions are employed. It is assumed that the mean and variance of each of the n buyers are related in the following way:

$$\mu_i = \alpha_i \mu_1$$

and

$$\sigma^2_i = \alpha^2_i \sigma^2_1$$

where

$$0 < \alpha < \infty$$

and

$$\alpha_1 = 1$$

This formulation assumes that the PDF of all buyers in the insurance pool can be described as a stretched or contracted version of some given PDF. It indicates also that when the average outcome increases, the variance of outcomes also increases. Finally, this assumption implies that the probability in the insured portion of the distribution is the same for all farmers. This is shown in Figure 5.3 where the cumulative probability, P, is the same for both buyers but the average indemnity $(a\mu P - Y)$ for buyer one is a stretched version of the average indemnity for buyer two. The amount of stretch is measured by the α factor. A test of the degree to which this assumption accurately describes the farming population will be performed in Chapter 6.

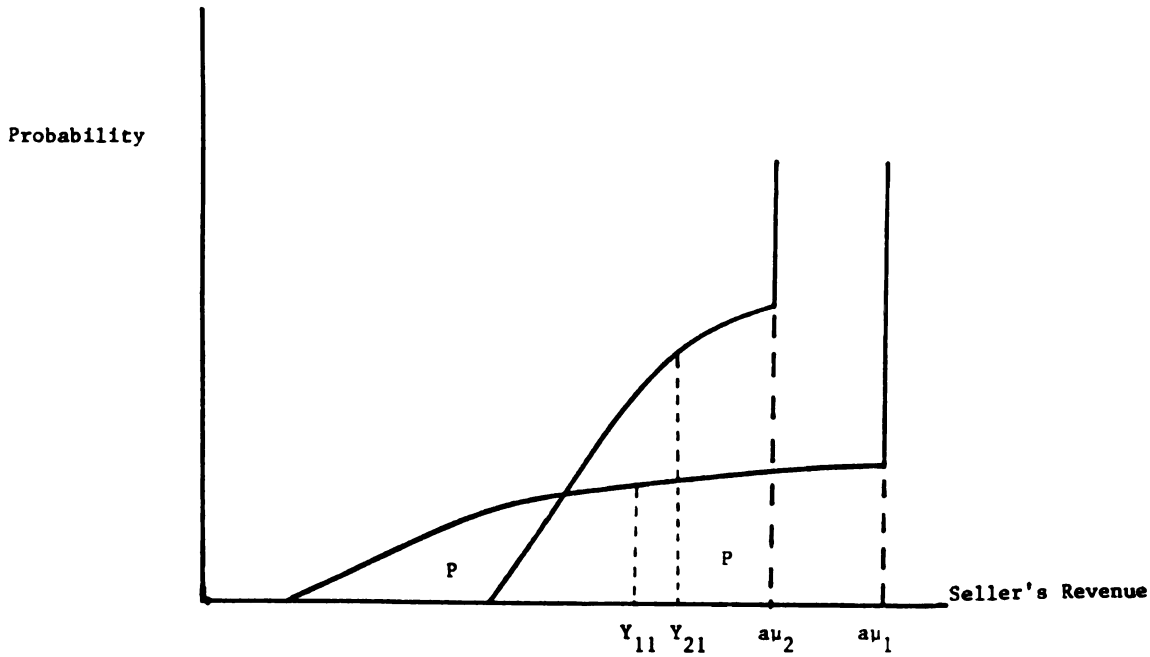

Figure 5.3: The PDFs of Two Buyers.

Where

$$\alpha_1 (a\mu_2 - Y_{21}) = a\mu_1 - Y_{11}$$

Given the above definitions for the mean and variance, and the definition for the loading factor (see equation (4.9) in Chapter 4), the loading factor for buyer i is defined as:

$$\phi_i = 1 - \lambda_i \alpha_i (a\mu(1 - P) - Y_2) \qquad (5.3)$$

This means that the loading factor for each client may be different, either because his risk aversion coefficient or his stretch factor is unique.

The model will be further constrained by the following assumptions:

$$a_i = a_1$$

$$C_i = \alpha_i C_1$$

for

$$i = 1, \ldots, n$$

Neither of these assumptions is severely restrictive. Assuming all buyers are offered the same level of coverage is likely to describe how the actual revenue insurance program will operate. This is, for example, similar to the way the Federal All-risk Crop Insurance program currently works. The assumption that non-insurance costs are also adjusted by the stretch factor, α, indicates that higher level mean outcomes are only achieved by increased expenditures.

The Expected Value-Variance Model for the Insurance Seller

The seller's expected return was defined in equation (5.1) as the premium collected from each of its n clients less the sum of the average indemnities paid to those clients and non-indemnity costs. Given the simplifying assumptions detailed above, the expected revenue for the seller is written as:

$$E(R^S) = [\sum_{i=1}^{n} (1 - \lambda_i^B \alpha_i (a\mu(1 - P) - Y_2) - 1)(\alpha_i (a\mu P - Y_1))] - B \qquad (5.4)$$

$$= (a\mu P - Y_1)(Y_2 - a\mu(1 - P))(\sum_{i=1}^{n} \alpha_i^2 \lambda_i^B) \qquad (5.5)$$

The superscript B on λ indicates this is the buyer's risk aversion coefficient.

The variance of the seller's revenue is, as might be expected, a more complicated expression. To derive an expression for the seller's variance note that the expected returns for the seller from the ith buyer is:

$$E(R^S_i) = \int_0^{a\mu_i} (\pi_i - (a\mu_i - Y_i) - B)f(Y)dY + \int_{a\mu_i}^{\infty} (\pi_i - B)f(Y)dY$$

$$= \pi_i - (a\mu_i P - Y_{i1}) - B \qquad (5.6)$$

Following the pattern developed in Chapter 4, a new variable Z_i is defined as:

$$Zi = \begin{cases} Y_{i1} & \text{with probability } f(y) \\ a\mu_i & \text{with probability } (1 - P) \end{cases}$$

Therefore, the expected value of Z_i is:

$$E(Z_i) = Y_{i1} + a\mu_i(1 - P)$$

Which means that the variance of the seller's revenue caused by the ith buyer is:

$$Var(B_i) = Y_{i1}{}^2 + (a\mu_i)^2P(1 - P) - 2a\mu_i Y_{i1}(1 - P) + \sigma^2_{i1} + \mu^2{}_i P \qquad (5.7)$$

Given the definitions for the mean and the variance, equation (5) may be simplified to:

$$Var(B_i) = \alpha_i(Y^2_1 + (a\langle\rangle)^2P(1 - P) - 2a\mu Y_1(1 - P) + \sigma^2_1 + \mu^2 P \qquad (5.8)$$

As discussed above, the total variance of the seller will be equal to the sum of the variances associated with each of the n buyers plus two times the covariance matrix. This is expressed as:

$$Var(R^S) = \sum_{i=1}^{n} \sigma^{*2}_i + 2(\sum_{i=1}^{n} \sum_{j=i+1}^{n} \rho_{ij}\sigma^*_i\sigma^*_j) \qquad (5.9)$$

$$= \sigma^{*2}_1[\sum_{i=1}^{n} \alpha^2_i + 2(\sum_{i=1}^{n} \sum_{j=i+1}^{n} \rho_{i,j}\alpha_i\alpha_j)] \qquad (5.10)$$

Where,

ρ_{ij} = the correlation coefficient for buyers i and j.

Therefore, the certainty equivalent expression for the seller is:

$$CE^{S} = (a\mu P - Y_1)(Y_2 - a\mu(1 - P))(\sum_{i=1}^{n} \alpha_i^2 \lambda_i^B)$$

$$- (\lambda^S/2)[\sigma_1^{*2}[\sum_{i=1}^{n} \alpha_i^2 + 2(\sum_{i=1}^{n} \sum_{j=i+1}^{n} \rho_{ij} \alpha_i \alpha_j)]] \qquad (5.11)$$

Where

λ^S = the seller's risk aversion coefficient.

Optimization in the Seller's Market

What is the optimal coverage ratio for the seller to offer his pool of clients? To answer this question, simply differentiate equation (5.11) with respect to "a" and set the resulting expression equal to zero.

$$dCE^S/da = 0 = [\mu P(Y_2 - a\mu(1 - P)) - \mu(1 - P)(a\mu P - Y_1)](\sum_{i=1}^{n} \alpha_i^2 \lambda_i^B)$$

$$- \lambda^S [(a\mu^2 P(1 - P) - \mu Y_1 (1 - P))(\sum_{i=1}^{n} \alpha_i^2 + 2\sum_{i=1}^{n} \sum_{j=i+1}^{n} \alpha_i \alpha_j \rho_{ij})$$

$$+ (\sigma_1^{*2})(\sum_{i=1}^{n} \sum_{j=i+1}^{n} \alpha_i \alpha_j (\partial \rho_{ij} / \partial a))] \qquad (5.12)$$

If the expression $(\partial \rho_{ij} / \partial a)$ is not equal to zero the implication is that the purchase of insurance causes a change in the pattern of outcomes across farmers. One explanation for such a change would be moral hazard. If the insurance policy caused farmers to take less care of their crop when it looked as though it was not going to produce well or when the market price was very low, ρ_{ij} might increase when insurance coverage is increased. If the increase in the correlation coefficient is sufficiently large and positive, the expression in equation (5.12) will always be less than zero, implying that no optimal coverage ratio greater than zero would exist for the seller. In any case, if the correlation coefficient is positively related to the coverage rate, the optimal amount of insurance a seller will offer will be reduced relative to the case in which these factors are independent. For the moment, assume $(\partial \rho_{ij} / \partial a)$ is equal to zero.

Again, it is difficult to solve equation (5.12) for the optimal coverage ratio because this ratio appears implicitly in so many terms in the equation. To determine the relationships between optimal coverage offerings and the other model parameters, equation (5.12) is totally differentiated. The results of these differentiations are summarized in Table 5.1 and the equations from which the results are derived appear in Appendix 3.

Table 5.1: Changes in Optimal Coverage Offerings with Changes in Model Parameters

Differential	Sign
$da/d\lambda_i^B$	+
$da/d\mu$	?
da/dY	?
$da/d\alpha_i^2$	?
$da/d\lambda^S$	-
$da/d\rho_{ij}$	-

The signs of the derivatives in Table 5.1 are intuitively appealing. An increase in buyer i's aversion to risk will increase the seller's expected return (by increasing the loading factor) while leaving the seller's variance unchanged. Assuming the seller has constant or decreasing risk aversion, this will induce the seller to increase the coverage ratio offered. If, on the other hand, the seller becomes more risk averse or if the degree of correlation across clients' outcomes increases, the coverage ratio offered would be expected to fall. An increase in the seller's risk aversion or the correlation coefficient focuses its impact on the variability of returns, the first by increasing sensitivity to variability of returns and the second by increasing the magnitude of variability.

The ambiguity associated with a change in α_i stems from its effect on the PDF of the seller's returns. An increase in α_i causes both the mean and variance of the seller's returns to increase. It cannot be known, a priori, how the seller would react to these changes. Similarly, an increase in μ results in a larger mean and variance for the seller's return. Again, the sign of this derivative cannot be known without more information.

The reason an increase in Y_2 will have an ambiguous impact on the optimal coverage ratio offered is somewhat more involved. First, assume the increase in Y_2 is achieved without increasing μ. This is a situation analogous to the two cases discussed in the previous chapter. Suppose, for example, that Y_2 increases because probability is shifted from the insured portion of the PDF into the uninsured portion. This could be in response to the development of a new corn cultivar that performs better under a wide variety of conditions than do existing varieties but does worse under certain extreme circumstances. The shift in an adopting farmer's PDF resulting from this new variety is illustrated in Figure 5.4. From the seller's point of view, such a shift will increase the average indemnity paid but decrease the probability of paying out such a benefit. The seller's response to this sort of event will depend upon an intricate interplay of several factors: the loading factor, the risk aversion of buyers and seller and the correlation coefficient. An increase in Y_2 has an ambiguous impact on the loading factor because an increase in Y_2 could cause the difference $a\mu(1 - P) - Y_2$ to rise or fall since P and Y_2 will both be changing. An intuitively appealing argument for the ambiguous effect of this type of increase in Y_2 on the optimal loading factor is relatively straightforward. As long as μ is held constant, an increase in Y_2 implies Y_1 must fall. From the buyer's perspective this means an increase in the average indemnity he will receive. However, since P has fallen, the likelihood of receiving a payment is reduced. Because these two factors exert pressures in opposite directions, the optimal loading factor may increase or decrease when Y_2 increases and P falls. Since the buyer's behavior is uncertain, the seller's response is as well.

Finally, how does an increase in Y_2 of this sort affect the correlation coefficient? If this new variety reduces the importance of management decisions, the outcomes of farmers might be more highly and positively correlated. Such an effect would put downward pressure on the coverage level offered. In short, because there are a number of potentially countervailing factors associated with an increase in Y_2 the sign of the derivative (da/dY_2) is uncertain.

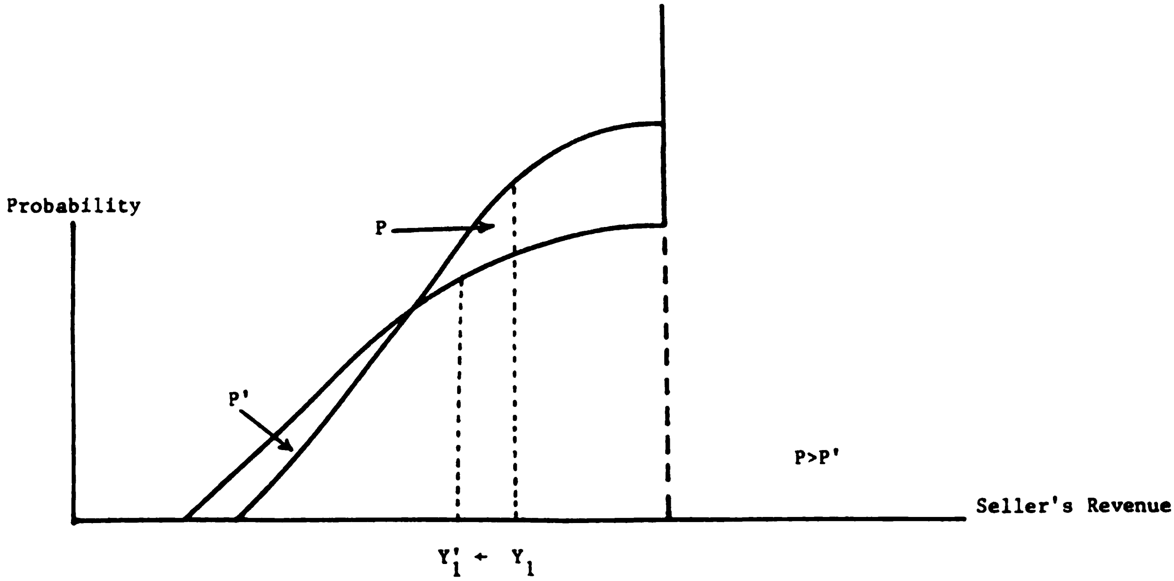

Figure 5.4: The Effect on the Seller's Revenue of a Shift in Buyer i's PDF in which Y_2 Increases and P Decreases

Conclusion

This chapter has presented an aggregate model of insurance supply that was deduced from results of a microeconomic model of demand. As far as I know, this is the first time this has been done. The advantage of this procedure is that the two sides of the insurance market are connected in a much more realistic manner than in most market models. In conventional models the assumption tends to be that as long as the seller is offering his product at a price that equals his minimum average cost, he can sell an unlimited quantity. The seller's sole motivation is assumed to be the maximization of profits. Neither of these assumptions is realistic. The models deduced in this dissertation assume that it is not only the level of expected revenue that is important to a decision maker, but its variability as well. Furthermore, the actions of buyers and the seller are related in important ways.

This procedure determines the reduced form equation of insurance supply. From this equation the relationships between the cost of insurance and model parameters were derived. The relationships deduced from this aggregate model highlight the fact that the seller's behavior in the insurance market is heavily dependent upon the behavior of its clients. For example, it was noted that if the correlation coefficient increased substantially when the coverage ratio increased, the seller might cease to offer insurance. To the extent that the program suffers from problems of moral hazard or adverse selection, the correlation coefficient of the insurance pool will increase. Both moral hazard and adverse selection are dependent upon the actions of buyers.

It was also found that an increase in the average indemnity paid (caused by an increase in Y_2, holding μ constant) will not automatically cause the seller to decrease the coverage offered its buyers. The seller's response will depend upon the type of shift involved. This is the seller's equivalent of the lessons learned in the previous chapter regarding buyer response to an increase in Y_2. This result is particularly interesting in view of the fact that many are concerned that a revenue insurance policy might induce producers to take more chances in their operations. If this turned out to be the case, the expectation would be that the variance of the farmer's revenue would increase. In this model this type of change is represented by an increase in Y_2 holding μ constant. The initial reaction is probably that this would cause the seller to decrease coverage, increase the price charged or both. This model predicts this will not necessarily be the case and will depend upon the nature of the shift.

These results illustrate the interdependence between buyer and seller in the insurance market. A seller's freedom to manipulate the loading factor he charges a client is circumscribed by the coverage level chosen by the buyer. The buyer's optimal coverage level is, in turn, dependent upon the loading factor he is charged. This emphasizes the point made by Hey regarding the intrinsic interdependence of supply and demand in an uncertain world. As Hey puts it,[2]

> "We see immediately that unlike the conventional (certainty) theory, we have a problem of consistency: the optimal behavior of the buyers depends upon what the sellers do; the optimal behavior of the sellers depends on what the buyers do. **It is no longer possible to analyse the two sides of the market separately, and then 'bolt them together' to get a market model.** (author's emphasis) The behavior of the sides must be considered simultaneously.

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1. Hey ,1979, Page 173

Chapter 6

An Empirical Test of the Theoretical Models

The models developed in this dissertation are based on a theoretical model of insurance demand. It is crucial that the models be tested for real world applicability and correspondence. This chapter describes the empirical tests to which the models were put and the results obtained.

The Empirical Model

The basic nature of the empirical test was to see if the model could accurately predict willingness to pay for insurance coverage. The willingness of a farmer to pay for insurance coverage is a function of the cost of the coverage, the value of the coverage (in terms of the frequency and size of indemnities received) and the individual's risk bearing propensities. Each of these parameters would be expected to vary from farmer to farmer. To facilitate the empirical phase of this study a computer program was written to calculate the premium each farmer should, according to the theoretical model, be willing to pay. The program is available from the author upon request. A portable computer was taken to each farm in the sample, data from the farm were entered and the respondent asked if he would be interested in acquiring a given level of protection at the stated price.

The model actually used in the field test was subsequently reformulated. The discussion to follow will focus on the reformulated model. The data from each sample farm were used in the reformulated model to generate new estimates for the premium predictions.

In the empirical phase of the study the coverage ratio was assumed to be set by the government at .5, .6 or .75. In Chapter 4, the premium was defined as:

$$\pi_i = \psi_i (a\mu P - \gamma_1)\alpha_i$$

If the coverage level is set, the choice for the farmer becomes, "How much would I pay for a given level protection, or, alternatively, would I participate if the premium was such and such?"

In Chapter 4 the optimal loading factor for a given farmer was defined by the equation:

$$\psi_i = 1 - \lambda_i \alpha_i^B (a\mu(1 - P) - \gamma_2)$$

Values for the parameters used to calculate the loading factor and the premium were derived for each farm. The premium forecast by the model could be more or less than an actuarially fair price if the individual's loading factor was more or less than one. Therefore, to determine the willingness of farmers to pay an amount that would just cover indemnities, the actuarially fair premium was also calculated. To calculate the premium required to just cover indemnities the probability weighted average payment received by a farmer, $(a\mu P - \gamma_1)$ was calculated.

A flow chart of the computer simulation program is presented in three parts in Figures 6.1, 6.2 and 6.3. In the first part of the program, illustrated in Figure 6.1, data are entered into the computer. The data required are the number of acres worked, the gross receipts from farming and the adjusted gross receipts (taxable income) for each of the ten years used as the base period. Gross receipts are converted to a per acre figure to eliminate the effect of changing farm size on gross receipts earned. Subsequently, both gross receipts and adjusted gross receipts per acre are converted to constant 1983 dollars. These real dollar/acre figures for revenue and income are multiplied by the number of acres in production in 1983 to generate PDFs for these variables for the farm's current size. The minimum and maximum revenue and income levels are then located by the program. The differences between the minimum and maximum revenue and income levels are each divided into five cells of equal size. Revenue and income histograms for the farm are generated by searching over the ten years of data and placing each revenue or income value into the appropriate cell. The the mean and variance of the income and revenue distributions are estimated from these histograms.

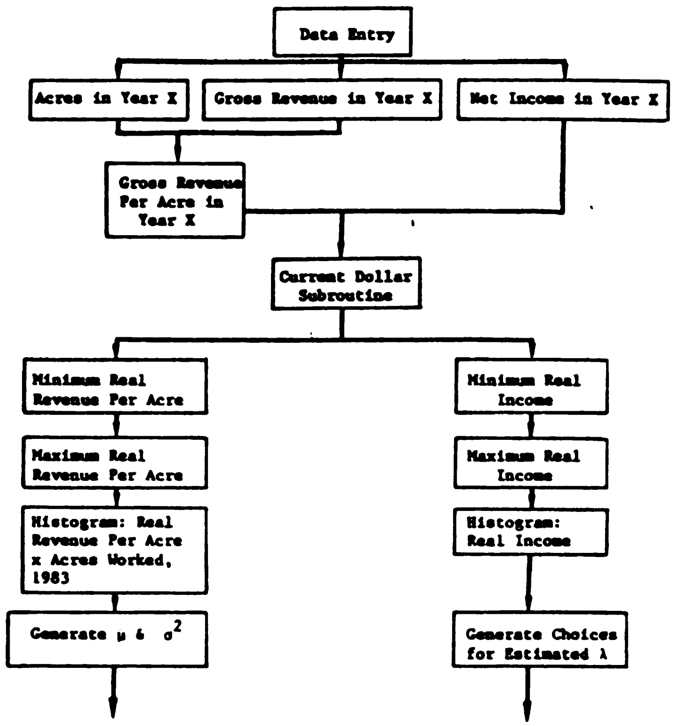

Figure 6.1: Part 1 of Computer Simulation Flow Chart - Data Entry and PDF Estimation.

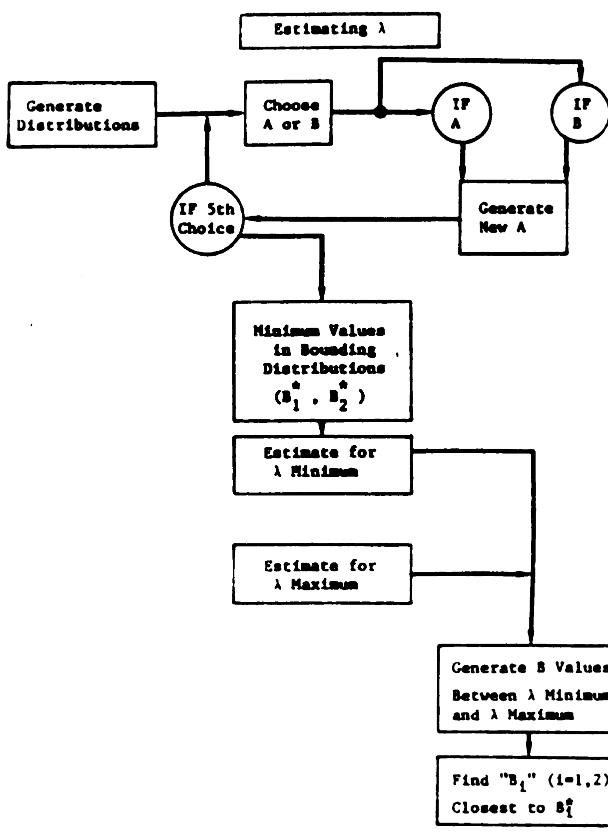

Figure 6.2: Part 2 of Computer Simulation Flow Chart - Estimation of the Farmer's Risk Aversion Coefficient.

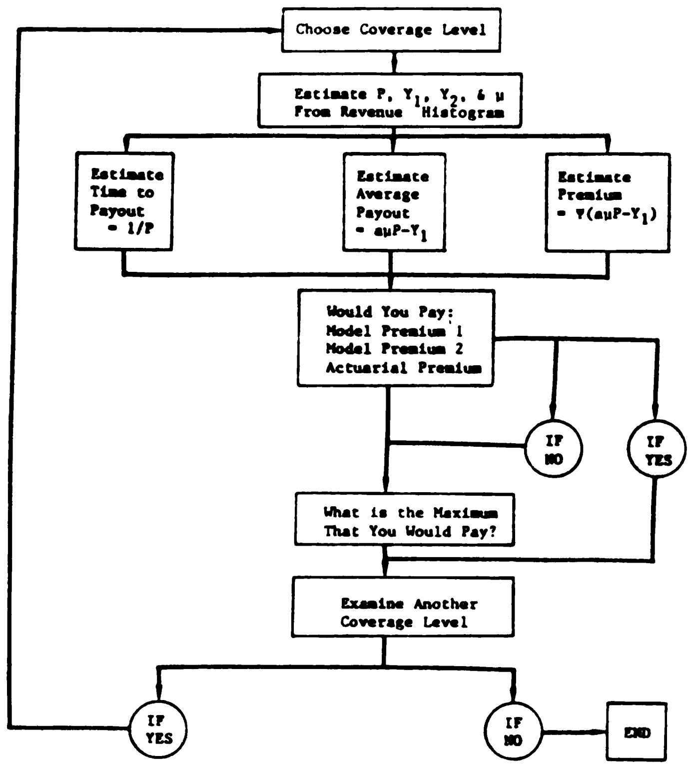

Figure 6.3: Part 3 of Computer Simulation Flow Chart - Premium Estimation.

In the second portion of the program, Figure 6.2, the buyer's risk aversion coefficient is estimated using the interval approach. The use of hypothetical distributions in eliciting risk coefficients has been criticized by numerous authors on a variety of grounds. Robison (1982) summarizes many of these complaints and concludes that despite the criticisms, the approach is a useful, albeit imperfect, predictive tool. To implement the interval approach, a series of choices between two distributions, each with six possible outcomes, is generated. An example of a choice pair appears in Table 6.1. The numbers in each distribution are described as levels of income the farmer could receive if he adopted an unspecified farm plan (A or B). Each value in a distribution is equally likely to occur.

In the actual survey, it was suggested that the farmer imagine he had one die in his hand and, having chosen a farm plan, he would roll the die. If a one resulted he would experience the first value in his chosen column (his chosen farm plan), a two meant he would get the second value and so on. Thus, if a farmer faced with farm plans A and B in Table 6.1 chose A and rolled a 4, he would receive $93,750 from farming in the current period.

In each pair of distributions the range of outcomes in choice B was twice that of choice A. The range of outcomes in Plan B represents the range of the farmers' actual income experiences over the base period. In the initial pair of distributions, such as the one listed in Table 6.1 and pictured in Figure 6.4, both farm plans have the same expected value. Based on the preference indication of the farmer the values in distribution A are recalculated and the decision maker is presented with another set of choices. For instance, if Plan A in Table 6.4 was selected, a new set of numbers would be generated for which the expected value would be less than that of Plan B. This new option, call it Plan C, would have a minimum value of $40,625, a maximum of $103,125 and a mean of $71,875.[1] Intermediate values will be placed at equal distances between the minimum and maximum. Plan C is less attractive than Plan A since the range is the same but the expected value is smaller. Based on the decision maker's preference for Plan C or B, the values in Plan C will be revised upward or downward. We are searching for a point of indifference between the two distributions. Since the interval method cannot locate the precise point of indifference, we search for the interval that contains this indifference point.

Table 6.1: Two Hypothetical Choice Distributions for Use in Calculating the Risk Aversion Coefficient of a Farmer.

Plan A Income Per Year	Plan B Income Per Year
56250	25000
68750	50000
81250	75000
93750	100000
106250	125000
118750	150000

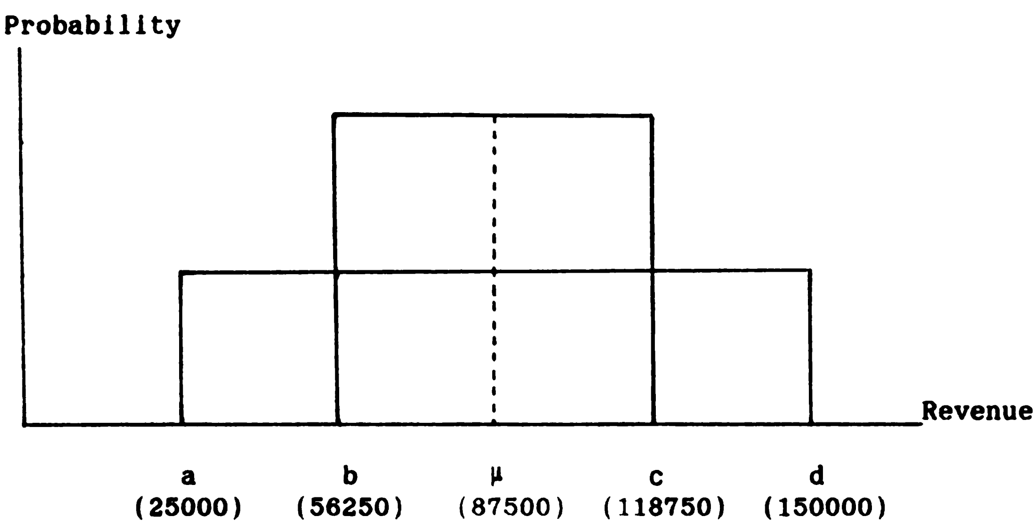

Figure 6.4: Two Distributions Used to Locate Indifference Points.

Figure 6.5 illustrates the choice tree faced by the buyer. Each choice node will bisect the remaining risk aversion space. Proceding out the ladder the range of values the decision-maker's risk aversion coefficient could take is progressively narrowed. Each farmer was presented with 5 pairs of distributions. The first four choices took the farmer to the final rungs in the ladder, the fifth choice was a consistency check. If the consistency check was failed, the interval expected to contain the risk aversion coefficient was doubled. For example, suppose a farmer opted for A, C, F and A in his first four choices. The fifth choice would again be between A and F. If the farmer now indicated a preference for A, the interval containing the risk aversion coefficient would go from L to K. If he again chose F, it would be from L to F. From this interval high and low estimates for the risk aversion coefficient were generated.

The number of choices offered to farmers in the interval approach will dictate the amount of Type 1 or Type 2 error contained in the estimate of the risk aversion coefficient. If few choices are offered, the likelihood that the decision maker's true risk aversion coefficient will be contained in the interval is quite high but the size of the interval is large. A large interval for the risk aversion coefficient means that the high and low bid price estimates for the insurance premium will be relatively far apart. If many choices are offered, more precise estimates of the farmer's risk aversion coefficient and bid prices are obtained but the likelihood of containing the true values of these variables is reduced. Based on pre-tests and the findings of King (1979), four choices were deemed to offer the best trade-off of these two types of error.

Numerical values for the risk aversion coefficients were estimated using the following formula.[2]

$$b = (-1/2\lambda) * (e^{-\lambda d} - e^{-\lambda a})/(e^{-\lambda((d-a)/2)} - 1) \qquad (6.3)$$

Equation (6.3) assumes the utility function for an individual can be represented by a negative exponential equation. At the point of indifference between two distributions the utility associated with a distribution over the range "a" to "d" is equal to the utility of the distribution running from "b" to "c". In Figure 6.4, indifference between the two distributions shown would indicate risk neutrality. If the values of "b" in the distributions that bound the farmer's point of indifference are less (greater) than those in Figure 6.4, the farmer is said to be risk averse (preferring).

It is probably impossible to solve directly for λ in equation (3). Therefore, to obtain estimates for the two risk aversion coefficients that bound the indifference point, a look-up routine was incorporated into the computer model. To begin this routine, recall that the certainty equivalent expression was:

$$CE = \mu + (\lambda/2)\sigma^2$$

Which means that

$$\lambda = 2*((\mu - CE)/\sigma^2) \qquad (6.4)$$

The minimum value in the distributions bounding the indifference point for the most risk averse individual will be "a" in Figure 6.4. Furthermore, for the most risk preferring person the minimum value in the bounding distribution would be no greater than the mean. These limits on the risk aversion coefficient correspond to concepts in the Game Theory literature. A person who would be indifferent between a distribution ranging from "a" (μ) to μ ("d") and one ranging from "a" to "d", is said to be a minimax (maximin) type of decision maker. A minimax (maximin) decision maker will always choose the distribution offering the smallest (largest) possible loss (gain). As this bounds the risk characteristics of the population, this range will contain the true risk aversion coefficient of our farmer.

By substituting "a" and μ for CE in equation (4) the range over which the computer must search for the individual's risk aversion coefficient is determined. One hundred values for λ spaced equally over this range are generated. These 100 values are used in equation(6.4)to estimate 100 values for "b". Having generated a vector of values for λ associated with a vector of values for "b", the computer performs the look-up procedure. The values for "b" from the two distributions bounding the point of indifference as estimated in the choice sequence discussed above, are entered. The computer then searches for the two values of "b" out of the 100 calculated that most closely approximate the entered values. The λs associated with these two "bs" become the estimates of the buyer's risk aversion coefficient.

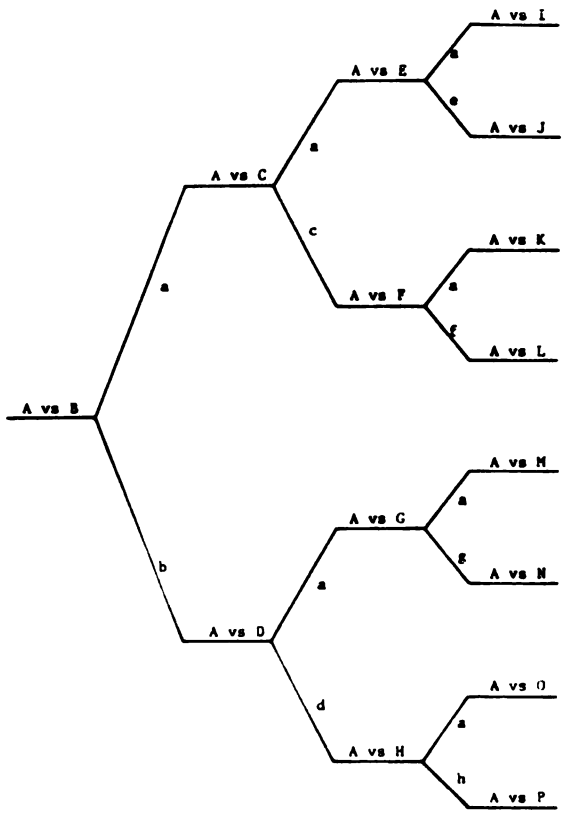

Figure 6.5: Choice Tree for Interval Approach to Risk Aversion Coefficient Estimation.

The third portion of the program estimates the premium the farmer should be willing to pay, assuming the theoretical models are correctly specified and the parameters correctly measured. In fact, three different premiums are estimated in this part of the program, high and low estimates based upon the theoretical model and the premium required for an actuarially fair program.

To obtain these estimates, the farmer is asked to indicate the level of insurance he would like to purchase, 50, 60 or 75 percent of his average revenue over the base period. If he is uncertain which coverage level he would prefer, he is allowed to examine all three levels. Based upon his coverage choice, the model parameters (μ, Y_1, Y_2 and P) are calculated from the revenue histogram developed in the first section of the program. The two estimates of the risk aversion coefficient from part 2 of the program are combined with these properties of the farmer's PDF over revenue to calculate the loading factor and the insurance premium. The actuarially fair premium is calculated directly from the farmer's PDF over revenue.

The farmer is then asked which of the three premium estimates he would be prepared to pay in exchange for the level of protection offered by the revenue insurance policy. The premiums are offered to the farmer in descending order of magnitude. For example, if the loading factor is greater than 1, the highest premium estimate will come from the theoretical model using the higher value for risk aversion coefficient. The next highest premium will be the theoretical estimate using the low risk aversion estimate and the least expensive estimate will be the actuarially fair price. If the farmer is unwilling to pay any of these amounts, he is asked to indicate the maximum he would consider paying.

The respondents were told that in exchange for the premium, they would be assured of a minimum return of so many dollars per acre in the coming crop year, that they could expect to receive an indemnity of so many dollars from the policy and that, on average, they would make a claim on the policy one year out of X. Suppose, for example, the farmer in question has annual gross receipts that average $100,000, he opts for 75% coverage, the probability in the insured tail is .20 and the average outcome over the insured portion of the PDF is $10,000. In exchange for a premium, this farmer would be assured that his gross receipts in the coming year would be at least $75,000. On average this policy will pay out $5,000 in benefits and a claim will be made on it one year out of five.[3]

The Sample

A total of sixty farms from two areas of Michigan, the "Thumb" and the south-central regions, were randomly selected from Cooperative Extension Service census lists as participants in the study. Of the sixty selected, nine were deemed to be inappropriate subjects, sixteen were unavailable and fifteen refused to cooperate. Furthermore, of the twenty who did participate, four had to be excluded for a technical reason, to be discussed shortly, and one because the data obtained were clearly inaccurate. The final sample was, therefore, fifteen farmers. Table 6.2 summarizes some of the characteristics of the 20 farms visited. The average size of the farms included in the final sample of 15 was probably smaller than the average commercial farm in Michigan. The size of the five farms excluded were larger than the sample average. Gross receipts per acre averaged \$201.09 for the farmers included in the final sample. A wide variation in gross returns per acre was also observed (from \$48.05 to \$439.43 per acre). While data were not collected on the age of the operator, the researcher's qualitative opinion is that the average age of the operators in the final sample was above the average for farmers as a whole. For example, the sample contained 4 farmers who were "semi-retired". The sample included two dairy operations, a swine operation, a cattle rancher and eleven cash-crop farms of various types, mainly corn, dry beans, and wheat.

Table 6.2: Summary Description of Farms Visited

	Farm	Acres Worked	Average Gross Receipts	Ave. Gross Receipts Per Acre
Farms in Final Sample				
	1	120	$20,945.00	$174.54
	2	1200	$293,168.00	$244.31
	3	490	$50,001.30	$102.04
	4	500	$98,903.00	$197.81
	5	360	$136,403.00	$378.90
	6	360	$100,007.00	$277.80
	7	260	$62,824.10	$241.63
	8	233	$11,196.70	$48.05
	9	402	$62,445.30	$155.34
	10	700	$163,120.00	$233.03
	11	176	$41,565.00	$236.16
	12	220	$44,070.90	$200.32
	13	1200	$259,907.00	$216.59
	14	76	$11,584.30	$152.43
	15	31	$4,801.04	$157.41
Mean Final Sample		422	$90,729.44	$201.09
Excluded Farms				
	1	780	$342,756.00	$439.43
	2	450	$118,355.00	$263.01
	3	280	$58,699.00	$209.64
	4	1300	$369,771.00	$284.44
	5	500	$214,279.00	$428.56
Mean Excluded Farms		662	$220,772.00	$325.02
Overall Mean		482	$123,240.08	$232.07

The Data

For the twenty farms that participated, average annual gross receipts from farming were estimated from tax data supplied by the farmer. Total gross receipts, as reported on schedule F of the farmer's tax records, for as many of the years from 1974 to 1983 as were available, were used as the base period.

There are several reasons why tax data might be deemed unsatisfactory for the purpose at hand. The most important problem is that farmers are allowed to use cash, as opposed to accrual, accounting in estimating taxable income. Therefore, these records do not necessarily measure receipts from a single crop cycle. There are two important components to this argument. First, farmers can, and regularly do move revenue and income between tax years by timing purchase and sales decisions. Thus, the tax record is likely to understate the variability of a farmer's revenue record. Second, since tax records do not include the value of inventory adjustments within a tax year, receipts reported for tax purposes may contain revenue earned from several different crop cycles. A third problem with using tax records are that they are sensitive records which some farmers are reluctant to show to others. These are some of the obvious shortcomings that must be accepted if tax records are used for the purposes discussed. The overwhelming advantage of using tax records for estimating costs and benefits of a revenue insurance program is their availability. Most farmers do have a relatively comprehensive record of tax receipts (if they are willing to share them). On the other hand, many farmers simply do not have records on sales from a given crop cycle and, by implication, changes in inventories.

As noted in Chapter 4, the risk aversion coefficient should not be estimated over gross receipts since ones attitudes toward risk are less likely to be determined by the total number of dollars flowing through ones pockets than by the number that stick there. A preferable variable over which to measure risk aversion would be a comprehensive measure of wealth such as end-of-period owner's equity. Unfortunately, many farmers do not have data on their end-of-period owner's equity and fewer still have such records covering a ten year period. It was, therefore, deemed necessary to proceed using annual income from all sources to measure risk attitudes. These data were also obtained from the participant's tax receipts.

Four farms were excluded from the final sample for what was termed a technical reason. The reason for their exclusion was that the maximum insurable level, 75 percent of the mean, was less than the minimum level of gross receipts experienced by the farmer over the base period. This being the case, the term $(a\mu P - Y_1)$ vanishes from the premium calculation, meaning that the buyer should be unwilling to pay anything for the insurance coverage offered. The implication is that the farmer has found alternative ways of stabilizing his revenue and, therefore, the insurance coverage has no value to him. This also means that the pool of participants for a revenue insurance program is unlikely to include the entire farm population.

There is an additional implication to be drawn from the four exclusions. In Table 6.2, note that the mean revenue of the excluded farms exceeds that of the 15 farms included in the sample. Since they were excluded because their variances were small relative to their mean, this contradicts the assumption underlying the aggregate models of Chapter 5. Specifically, the aggregate model assumed that the mean and variance of individuals in the pool could be described as stretched or contracted versions of some standard PDF. This means that in order to obtain a higher mean, a relatively greater degree of variance would have to be accepted. For at least four of the individuals in the sample, higher means were achieved without a large increase in variance.

Results

The first question to be examined empirically is how well does the model predict willingness to pay for insurance coverage? If it does successfully predict willingness to pay, what conclusions can be drawn about the potential cost of the program? Specifically, if the price of coverage is sufficiently low, a high participation rate can be ensured but the cost of the program to the government will be high. A question of interest is, therefore, the loading factor that farmers would be willing to pay for revenue insurance coverage, since this will determine the amount above indemnity costs that farmers might willingly pay. If farmers are willing to pay a premium that is greater than an actuarially fair one, then some of the administrative costs of the program would be covered by their premiums. Yet another issue is the effect of an increase in the variability of outcomes on the cost of insurance.

At a more aggregate level there is the question of the justifiability of the simplifying assumptions made concerning the PDFs of the clients in an insurance pool? The shape of the aggregate demand curve is also of concern. Aggregate demand will be derived by exploring the relationship between participation rates and the loading factor. Finally, the data can be used to examine the effect of different subsidy rates on the cost of supplying revenue insurance.

Table 6.3 summarizes some of the results of the model trials with respect to farmer willingness to pay for insurance coverage. The results discussed are for coverage at 75 percent of the mean. Few data were available for coverage at the 50 and 60 percent levels. Many farmers inquired about these levels of insurance but few had experienced revenue levels below the 50 and 60 percent levels during the base period and were, therefore, excluded for the technical reason discussed above. It was felt that the small numbers of respondents who did qualify, could not give a very useful picture of demand for insurance at these levels. As noted at the outset, the actual field trials were conducted using a different model. The column headed original maximum bid price lists the maximum bid price offered by the farmer in the field tests. The third and fourth columns list the high and low bid price estimates of the revised model. In the best case, the new estimates would have bounded the old maximum bid price. Only two of the predictions did bound the old bid price. However, the low and high average premiums do bound the average maximum bid price from the original model. It is also very encouraging that in only three of the fifteen cases did the model fail to produce a premium that the farmer would be willing to pay. This is shown by comparing the original bid price with the bid price predicted by the revised model. If any of the revised model predictions are less than the original bid price, it is assumed that the farmer would pay this amount. Therefore, only the 6th, 7th and 9th farmers would not have found a premium they would have paid under the revised model. Finally, the fact that premiums predicted by the model are, with few exceptions, of a believable magnitude is also encouraging.

The average annual indemnity received by each farmer is listed in the fifth column of Table 6.3 and the probability of obtaining an indemnity is listed in the sixth column. The final column lists the estimated risk aversion coefficient for each farmer. A positive (negative) value of implies risk averse (loving) attitudes.

TABLE 6.3: Model Performance and Insurance Characteristics of the 15 Farms Studied, for 75 percent Coverage.

Farmer	Original Bid Price Per Acre	High Estimate Per Acre	Low Estimate Per Acre	Ave. Indemnity Received/Acre	Probab. Indemnity	Lambda
1	1.90	.86	.73	.42	.1114	.00020
2	6.32	.41	-3.12	2.02	.1031	-.00002
3	4.99	.32	-2.91	1.88	.1119	-.00003
4	9.07	12.51	6.93	2.16	.1286	.00030
5	6.91	9.94	3.89	6.91	.2697	.00001
6	1.86	27.29	20.94	7.36	.4219	.00013
7	.77	24.93	17.81	2.69	.1806	.00027
8	13.13	2.44	2.01	2.01	.3002	.00007
9	5.00	11.28	6.16	1.50	.1162	.00040
10	2.64	2.54	1.51	.64	.1320	.00007
11	3.77	1.69	1.41	.79	.0710	.00011
12	6.03	3.10	2.33	1.53	.1603	.00009
13	4.49	-.19	-4.48	1.33	.1341	-.00002
14	2.47	1.11	.54	.01	.0164	.00011
15	10.00	8.89	6.66	7.68	.3549	.00011
Average	5.29	7.14	4.03	2.60	.1742	.00012
Standard Deviation					(.1123)	

The high estimate of the revised model provided per acre premium estimates of a reasonable size and in the area of the maximum bid price voiced by the buyer for most cases. However, several of the estimates were not at all close to the original value. In particular when an individual indicates he is risk preferring in the second portion of the computer simulation, the estimates for the maximum bid price tend to bear little resemblance to the maximum bid price expressed by the farmer. This highlights several points. First, we would not expect to find farmers who are risk preferring. Being a lover of risks implies a propensity to go against the odds. In the long run, going against the odds will always be a losing proposition. If a farmer was truly risk preferring he would eventually go out of business as the odds catch up with him. It is, of course, possible to exhibit risk preferring behavior in a given instance. This is borne out by the discussion of Ehrlich and Becker as well as Robison and Lev (1984). But, we would not expect to see risk preferring behavior consistently and and in the long run.

Second, the seeming inability of the model to perform well for ostensibly risk preferring buyers indicates that care must be taken in the implementation and interpretation of models of this sort. Clearly the results of the model are extremely sensitive to the risk aversion coefficient. The derivation of this parameter is not without pitfalls. Beyond the theoretical questions surrounding the interval approach using hypothetical values, there are a number of implementation issues of tremendous importance. Experience with implementation indicates that the process is difficult to explain in a way that is clear to the farmer without introducing the possibility of interviewer bias. There is, in addition, the problem of type 1 versus type 2 error discussed above.

The discrepancies noted for farmers 6 and 7 point out, I believe, the importance of data quality and quantity for the successful use of this model. In both cases the farms had undergone extensive reorganization in the recent past. It was felt that the revenue record of the farm prior to reorganization would not provide an accurate picture of the revenue experience of the farms as currently operated. Thus, both farms had considerably less than the ten years of data sought for the base period. In addition, each of these farmers indicated relatively strong risk aversion. Relatively unstable earnings (caused at least in part by the limited length of data series) and high risk aversion combined to increase dramatically the estimated bid price for these two farmers.

The results from farmers 6 and 7 are particularly instructive because these were both relatively young farmers. Their situations reflect several questions which must be addressed by any revenue insurance program that is implemented. First, since these two farmers had been on their own for a relatively short period of time they did not have a lengthy revenue record. Much as the young driver pays relatively high insurance prices to insure his vehicle because he is unable to prove he is the exception to the rule, a safe and prudent teenage driver, young farmers will face a similar problem when signing up for revenue insurance. The solution to this problem in the crop insurance program has been the liberal use of county data to supplement (replace) own-farm data. For the reasons discussed in Chapter 2, this is not a wholly adequate solution.

These cases raise the larger question of how the insurance program will handle policies for farms that undergo major changes in organization; the break-up of a partnership, a substantial change in farm size, a change in the types of crops or livestock produced and so on. This presents the policy maker with a dilemma. Farm reorganizations are often a very necessary action and it seems unfortunate that young farmers are penalized simply because they haven't been in farming for very long. However, the policy maker does not want to reduce the amount of information conveyed by the insurance premium regarding market conditions. Specifically, a lower premium is the reward for management decisions that, in the view of the insurance company, are prudent; ones that reduce the variability of earnings.

The issue is, therefore, how a revenue insurance program can be structured so that it doesn't unduly punish young farmers and farmers who alter the organization of their operation yet retains the ability to convey market information.

In Chapter 4 the possibility that young farmers might have a greater propensity to purchase revenue insurance was discussed. The relatively large risk aversion coefficient of farmers 6 and 7 may be indicative of this greater propensity. As discussed in Chapter 4, since young farmers are less likely to have built up much equity in their farm and will have a smaller credit reserve, they will probably be more sensitive to down-side risks. This could easily explain an unusually high propensity to purchase revenue insurance amongst young farmers. This propensity may, however, be outweighed by the need to control cash expenses and the relatively higher prices demanded by insurance companies to cover their risks. For this sample, the desire to control down-side risks seems to have been of greater relative importance.

One of the more surprising aspects of Table 6.3 is the relatively low cost of revenue insurance in terms of benefits paid out per acre. Not only is the overall average indemnity under $3.00 per acre per year, but none of the individual average indemnities exceeds $8.00 per acre per year. The low indemnities are probably the result of several factors, two of which may be of transcendent importance. First, as noted in Chapter 2, the expected negative correlation between price and quantity should make the revenue PDF more stable than either the price or quantity PDFs individually. Second, the use of tax data could, for the reasons stated above, overstate the degree of stability of revenue. Additional factors explaining the observed stability might be model misspecification, an insufficiently long base period or an unrepresentative sample.

Finally, the distribution of the cumulative probabilities listed in the sixth column of Table 6.3 is quite remarkable. In the model of aggregate supply developed in Chapter 5, the hypothesis was that the probability in the insured tail of each buyer's PDF was the same but that the distribution of that probability was stretched or contracted by the factor α. In eleven of the fifteen cases listed in Table 6.3 the probability in the insured portion of the PDF is within plus or minus one standard deviation of the average of .1742. In contrast to the implication drawn from the exclusion of the four farmers who had high mean-low variance outcomes, this phenomenon supports the assumption employed. In the aggregate more than 50 percent of the farms in the sample seem to be quite adequately described by the simplifying assumptions.

Aggregate Results

The aggregate models use the assumption that the PDF of each buyer in the market can be described as a modified version of some standard PDF. In the empirical test of the aggregate model the numeraire distribution was assumed to be the average PDF. That is, it is assumed that an individual's PDF can be approximated by multiplying the mean, Y_1, and Y_2 for the insurance pool by the appropriate shift factor, α. In Table 6.4 the mean return for the fifteen farm sample is given as $93,159.31, Y_1 as $10.887.80, and Y_2 as $82,271.51. The loading factor and premium for buyer i are, therefore, defined as:

$$\psi_i = 1 - \lambda_i \alpha_i (.75(93159.31(1 - .17)) - 82271.51)$$

$$= 1 - \lambda_i^{B} \alpha_i (-24279.84)$$

and

$$\pi_i = \psi_i \alpha_i (.75(93159.31(.17)) - 10887.80)$$

$$= \psi_i \alpha_i (990.01)$$

where

$$\alpha_i = (\mu^*_i/93159.31)$$

Table 6.4 lists the α for each buyer and compares the loading factor and premium/acre generated by the model developed in Chapter 4 to the loading factor and premium generated when the simplifying assumptions of Chapter 5 are employed. The loading factors listed as coming from the Chapter 4 model use the high estimate for the risk aversion coefficient. Likewise, the premiums in the next to last column use the high estimate for λ.

There is a remarkably good fit between the values for the loading factor calculated in the two different ways. While the differences between individual premium estimates are substantially greater than those observed for the loading factor, the difference between overall average premium estimates is also extremely small.

Table 6.4: Comparison of Measured and Estimated Values for the Loading Factor and Premium.

Farmer	Mean Revenue	Alpha	Chapter 4 Loading Factor	Chapter 5 Loading Factor	Chapter 4 Premium Estimate(a)	Chapter 5 Premium Estimate(a)
1	20945.00	.22	2.04	2.09	103.49	600.88
2	136403.00	1.46	.20	.17	148.86	323.41
3	100007.00	1.07	.21	.18	144.60	250.54
4	62824.00	.67	5.80	5.89	3251.68	5018.76
5	293168.00	3.15	1.44	1.39	11923.10	5584.66
6	66668.00	.72	3.71	3.36	13372.90	3073.85
7	118685.00	1.27	9.26	9.33	12465.40	15206.64
8	11196.70	.12	1.21	1.19	567.38	183.35
9	62445.00	.67	7.51	7.62	4534.25	6537.56
10	163120.00	1.75	3.95	4.05	1778.28	9086.00
11	41565.00	.45	2.15	2.19	297.49	1253.54
12	44071.00	.47	2.02	2.05	681.66	1238.82
13	259907.00	2.79	-.14	-.17	-226.09	-590.25
14	11584.00	.12	1.32	1.34	83.99	212.63
15	4801.00	.05	1.16	1.14	271.21	75.14
Average	93159.31	1.00	2.79	2.79	3293.21	3203.70

$Y_1 = 10887.80$

$Y_2 = 82271.51$

(a) Annual premium.

Several interesting patterns emerge from Table 6.4. First, at least in the aggregate, the simplifying assumptions employed in Chapter 5 provide an accurate picture of the insurance market. The fact that the cumulative probability contained in the insured portion of many of the buyer's PDFs is quite similar and the extremely good estimates of the loading factor obtained when the simplifying assumptions are employed, leads to the conclusion that the lower reaches of the PDFs of our fifteen farmers are fairly similar. The fact that the premium estimates differ by considerably greater amounts indicates that there are greater differences in the PDFs of the sample farmers over the uninsured portion of their PDFs. A much larger and more broadly drawn sample is required before much can be made of the patterns detected in the 15 sample farms. What can be said is that for this sample the differences between the loading factors and premiums calculated by the two methods are not significantly different from zero. The hypothesis that they are different from each other is tested and rejected in Table 6.5.[4]

Table 6.5: Test the Significance of Differences in the Loading Factor and Premium Estimates Using Two Estimation Techniques.

Loading Factor Chap.4	Loading Factor Chap.5	Diff.	Diff. From Mean Squared	Premium Chapter 4	Premium Chapter 5	Diff.	Diff. From Mean Squared
2.04	2.09	-.05	.0025	103.49	600.88	-497.39	247396.81
.20	.17	.03	.0009	148.86	323.41	-174.55	30467.70
.21	.18	.03	.0009	144.60	250.54	-105.94	11223.28
5.80	5.89	-.09	.0081	3251.68	5018.76	-1767.08	3122571.73
1.44	1.39	.05	.0025	11923.10	5584.66	6338.44	40175821.63
3.71	3.36	.35	.1225	13372.90	3073.85	10299.05	106070430.90
9.26	9.33	-.07	.0049	12465.40	15206.64	-2741.24	7514396.74
1.21	1.19	.02	.0004	567.38	183.35	384.03	147479.04
7.51	7.62	-.11	.0121	4534.25	6537.56	-2003.31	4013250.96
3.95	4.05	-.1	.0100	1778.28	9086.00	-7307.72	53402771.60
2.15	2.19	-.04	.0016	297.49	1253.54	-956.05	914031.60
2.02	2.05	-.03	.0009	681.66	1238.82	-557.16	310427.27
-.14	-.17	.03	.0009	-226.09	-590.25	364.16	132612.51
1.32	1.34	-.02	.0004	83.99	212.63	-128.64	16548.25
1.16	1.14	.02	.0004	271.21	75.14	196.07	38443.44
2.79	2.79	.0013		3293.21	3203.70	89.51	
SUM OF ERRORS SQUARED			.1690				216147873.46
STANDARD ERROR			.1099				3929.27
T-COEFFICIENT			.0458				.0882

The Effect of Increased Instability on Premium Costs

One of the shortcomings of using tax data is that the stability of a farmer's revenue experience is likely to be overstated. A simple, and somewhat imperfect, way of examining the sensitivity of the model to increases in instability is to increase the value of α. Increasing α, ceteris paribus, is an imperfect test because this increases the mean as well as the variance of outcomes. To generate the numbers in Table 6.6, the alpha value for each farmer was doubled. The original estimates for the loading factor and premium (employing the original value for α) are repeated from Table 6.4 in the final two columns of Table 6.6.

Perhaps the most interesting feature of Table 6.6 is that doubling α increases the average premium by more than a factor of three. The implication is that the premiums might increase substantially with an increase in the variability of outcomes. The increase in the premium predicted by the model is not constant across farms, however. The most obvious examples of this are farmers 2 and 3. An increase in α for these two farmers would, according to the model, cause both farmers to reduce the amount they would pay for insurance by a substantial amount. In fact the loading factor for these two purchasers changes sign with the doubling of alpha.

The other outstanding feature of Table 6.6 is the extreme values predicted for some of the premiums. Quite clearly no one is going to pay over $115/acre to obtain the protection offered by revenue insurance. This extreme value is explained in part by the limited number of years included in the base period of farmer 7 and partly by the assumption that the risk aversion coefficient for the farmer remains constant despite the fact that we have increased his expected revenue level relative to the first case.

Table 6.6: Comparison of Measured and Estimated Values for the Loading Factor and Premium When Alpha Doubles

Farmer	Alpha	New Loading Factor Estimate	New Premium Estimate	New Cost/ Acre	Old Loading Factor Estimate	Old Premium Estimate
1	.45	3.18	$1828.03	$15.23	2.09	$600.88
2	2.93	-.65	-$2454.23	-$6.82	.17	$323.41
3	2.15	-.64	-$1745.67	-$4.85	.18	$250.54
4	1.35	10.78	$18600.86	$71.54	5.89	$5018.76
5	6.29	1.77	$14283.44	$11.90	1.39	$5584.66
6	1.43	5.71	$10463.61	$21.35	3.36	$3073.85
7	2.55	17.65	$57565.52	$115.13	9.33	$15206.64
8	.24	1.38	$425.75	$1.83	1.19	$183.35
9	1.34	14.24	$24434.48	$60.78	7.62	$6537.56
10	3.50	7.11	$31862.06	$45.52	4.05	$9086.00
11	.89	3.39	$3871.31	$21.99	2.19	$1253.54
12	.95	3.09	$3744.35	$17.02	2.05	$1238.82
13	5.58	-1.33	-$9502.30	-$7.92	-.17	-$590.25
14	.25	1.67	$532.22	$7.00	1.34	$212.63
15	.10	1.28	$168.66	$5.53	1.14	$75.14
Average		4.58	$10271.87	$25.02	2.79	$3203.70

The Aggregate Demand Curve

The aggregate demand curve for the fifteen farms is in terms of the loading factor charged and the number of farmers participating. One reason for interest in the aggregate demand curve is to be able to answer the question: 'If the government is going to use a single loading factor to calculate the premium, what should it be?' Put another way, if the government wanted to achieve some level of participation in the program, 75 percent of all full time farmers for instance, what is the maximum loading factor it could charge? Figure

6.6 shows the relationship between the loading factor and participation. As we would expect, greater participation is achieved as the loading factor is lowered.

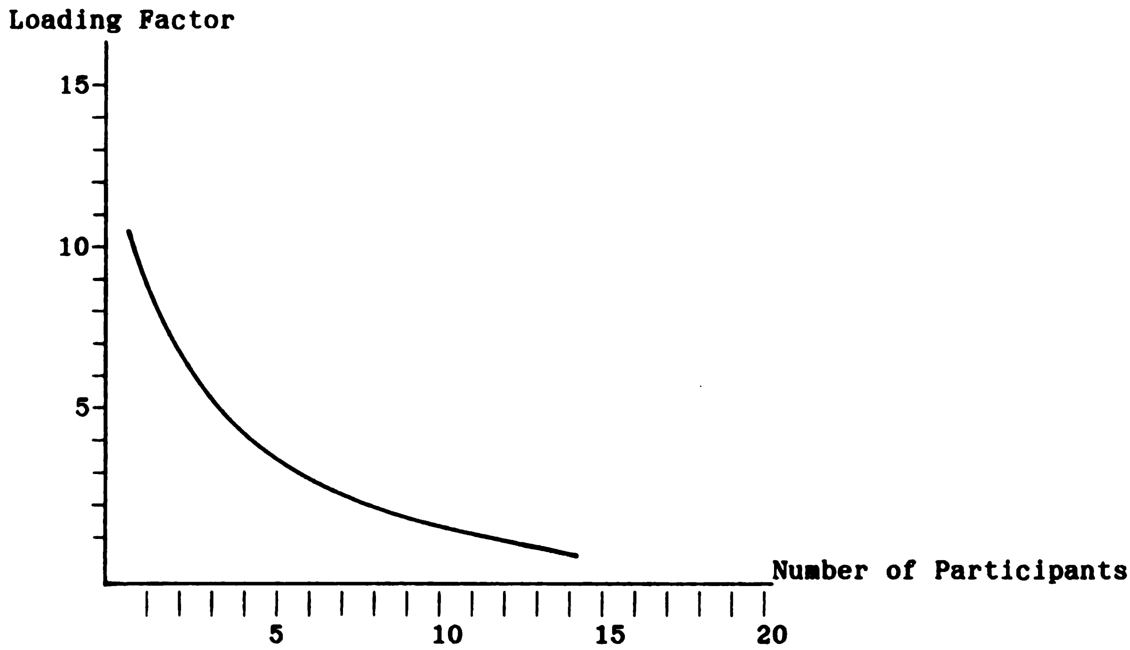

Figure 6.6: Participation as a Function of the Loading Factor

The relationship between the gross receipts the government could expect to receive and the loading factor is plotted in Figure 6.7. Gross receipts increase as the loading factor increases until it reaches 4.00, at which point they begin to fall. It is interesting to note that only slightly more than one in four farmers would be expected to participate if the loading factor was 4.00. This implies that there is probably a positive relationship between expense to the government and levels of participation.

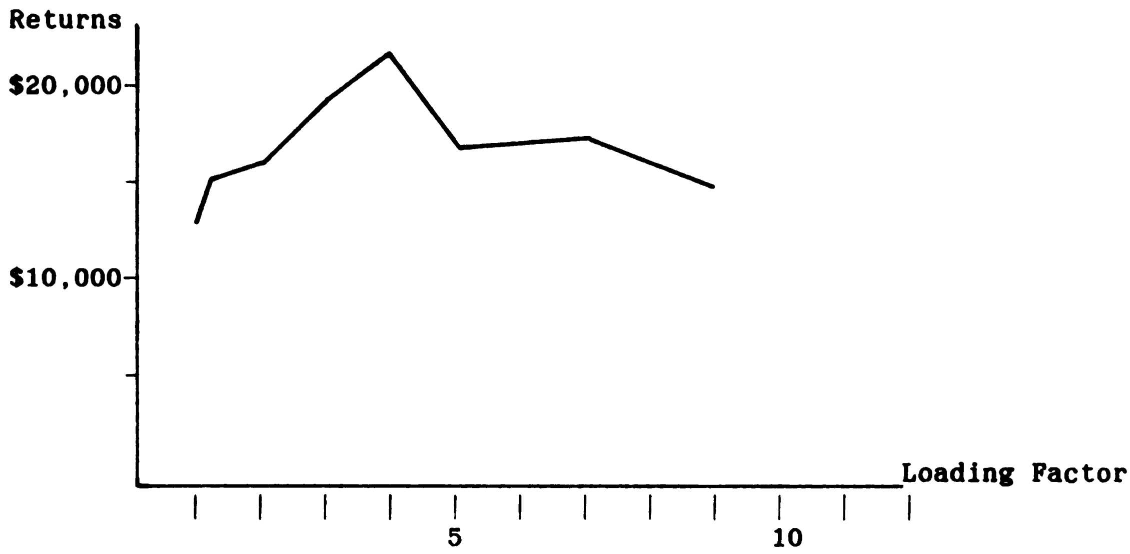

Figure 6.7: Expected Returns in a Revenue Insurance Program for Different Loading Factors.

Table 6.7 summarizes the relationships between the loading factor, the participation percentage, revenue for the seller and the surplus that would be available to the seller to offset non-indemnity costs.

Table 6.7: Participation Rates, Seller's Returns and Seller's Surplus as Related to the Loading Factor

Loading Factor	Percent Participation	Average Indemnities	Seller's Returns	Seller's Surplus
9.00	6.7	1630.52	14674.65	13044.13
7.00	16.7	2488.40	17418.78	14930.38
5.00	20.0	3351.49	16757.43	13405.94
4.00	26.7	5592.46	22369.83	16777.37
3.00	33.3	6508.36	19525.07	13016.71
2.00	53.3	7972.60	15945.17	7972.57
1.25	66.7	12159.34	15199.16	3039.82
1.00	80.0	12379.10	12379.10	0.00

In the analysis to follow, it is assumed that the loading factors calculated from the aggregate model and reported in Table 6.4 are accurate. Thus, if farmer 1 has an optimal loading factor of 2.09, this is taken to be an accurate measure of his willingness to pay for revenue insurance protection. It is also assumed, quite reasonably, that if he would pay a premium based on a loading factor of 2.09, he would be willing to pay one based on a loading factor of 2.00. Use of a smaller loading factor simply means he will get the same level of coverage at a lower price.

Now, suppose the government wanted to assure that two-thirds of the farmers in the sample will participate in a revenue insurance program. Based on the results reported in Table 6.7, the government could charge a flat loading factor of 1.25 and obtain the desired level of participation. This means that the government could expect to be able to use roughly twenty-five percent of the premiums collected to off-set the cost of administering the program. For example, based on Table 6.4, if the government used a loading factor of 1.25 we would expect farmers 1, 4, 5, 6, 7, 9, 10, 11, 12, and 14 to participate in the program. Based on the figures in Table 6.7, the government could expect to earn $15199.16 from these ten farms and have over $3000.00 to use for operating expenses. If the approximate cost of administering a revenue insurance program was known, an estimate of the drain this type of program would make on the federal budget could be made.

Insuring a given percentage of the land in agricultural production may be of greater interest than insuring a given percentage of the farming population. Table 6.8 examines the trade-off between the loading factor and the proportion of acreage insured. Comparing

Tables 6.7 and 6.8, we see that there is relatively little difference between participation rates as a function of the loading factor when measured on a participant or an acreage basis. One extremely important and interesting implication of this relationship, if it holds in the broader farm population, is that a revenue insurance program structured like the one analyzed in this thesis may be equally effective in attracting participants from small and large farms.

Table 6.8: The Proportion of Acreage Covered at Various Loading Factor Levels.

LOADING FACTOR	PERCENT ACRES IN PROGRAM
9.00	7.9
7.00	14.3
5.00	18.4
4.00	29.4
3.00	37.2
2.00	45.3
1.25	65.5
1.00	69.7

In summary, the models as formulated in this dissertation have performed remarkably well, at least on the admittedly small sample considered. In addition to the support lent to the theoretical models, the case studies have provided several valuable insights into the problems and potential of a revenue insurance program.

Qualitative Assessment

In addition to the numerical data collected from farmers, their subjective opinions about a revenue insurance program were sought. Several things about their responses were noteworthy. First, the fact that one-quarter of the farmers contacted refused to cooperate is indicative of a degree of disinterest in the subject in the farming community. Second, of the farmers who did participate in the study, the majority voiced a great deal of skepticism about the program. Many felt that it would be too easily manipulated by unscrupulous farmers. The opinion that the record keeping requirements would be more trouble than the program would be worth was also a common response. Others indicated a deep-seated suspicion of insurance companies, feeling that however the program was structured, they would be the loser. However, despite these rather negative reactions, virtually all indicated an interest in the program if the protection discussed was available at the prices indicated by this model.

Summary

The empirical work described in this chapter is the first effort to guage the cost of and farmer attitudes toward the proposed revenue insurance program. Many farmers indicated a lack of interest in the program by choosing not to participate in the study. In addition, those who did participate voiced a great deal of skepticism about the workability of the program. Despite this scepticism virtually all of the farmers in the sample voiced an interest in obtaining this type of protection.

The empirical data lend qualified support to the theoretical models constructed in Chapters 4 and 5. Before the strength of that support can be assessed, a much broader sample of farms will have to be surveyed. Based on the current sample, it appears that a revenue insurance program might be much less expensive to operate, in terms of indemnity payments, than expected. The evidence suggests farmers would, on average, be willing to pay somewhat more than an actuarially fair price for insurance of this type. This has important policy implications since it indicates that at least a portion of the administrative costs of the program could be off-set by farmers' premiums. A major qualifier to this assessment is that the data used could have a bias in favor of stability. If the data exaggerate the stability of farm revenue, the cost per acre of the program could increase dramatically and the willingness to pay a loading factor greater than one could fall. Finally, a revenue insurance program appears to have a similar degree of appeal across sizes of farms meaning, for instance, that participants in the program are likely to be drawn from all sizes of farms indicating that the effect of the program may be scale neutral.

The results of this survey should be interpreted as quite encouraging for those interested in a revenue insurance program. They indicate that there is a degree of resistance to the idea of revenue insurance in the farming community but that this skepticism can be overcome by a program offering protection at a price slightly greater than required for actuarial soundness.

Having completed the theoretical and empirical treatments of the revenue insurance option, it is time to step back and try to gain a broader perspective on the topic. The next chapter provides this perspective.

1. The minimum value for Plan C is midway between the minimums for Plans A and B. The range of Plan C is, like Plan A, one-half the range of Plan B. Thus to derive the maximum for Plan C, we add (125,000/2) to 40,625.

2. This formula was developed by Dr. Lee Sonneborn of the mathematics department at Michigan State University. Dr. Sonneborn's assistance is greatly appreciated.

3. The insured level, $a\mu$, is:

$$.75(100000) = \$75,000.00$$

The average indemnity, $a\mu P - Y_1$, is:

$$.75(100000(.2)) - 10000 = \$5,000$$

The years to payout, 1/P, is:

$$1/.2 = 5 \text{ years}$$

4. The t-statistic is derived from the following formula:

$$t = (\bar{X} - \mu)/(s/\sqrt{n})$$

Where

$\bar{X} - \mu$ = Mean of the difference between the Chapter 4 and 5 estimates.
s = Standard error of the estimate.
n = Sample size.

Chapter 7

Revenue Insurance in American Farm Policy

This chapter examine the likely impact of a revenue insurance program on two farm problems: low or variable farm incomes and unstable agricultural commodity markets.

Farm Income Problems and Revenue Insurance

Since the Great Depression, the U.S. has had a variety of public programs that have intervened in agricultural markets. At their inception, and for much of the time since, there was at least tacit agreement amongst most policy makers that the issue to be addressed by farm programs was the wide difference between the income levels of farm and non-farm households. There were many hypotheses put forward purporting to explain the problem of low incomes in agriculture: excessive amounts of labor or other inputs that were "stuck" in agriculture, outward shifts of the supply curve induced by technological change coupled with an inelastic and stable demand curve, the structure of agriculture vis-a-vis other sectors of the economy (competitive versus monopolistic or oligopolistic markets) to cite a few. Others argued that the problem was overstated because of a statistical illusion (farmers were better off than statistics implied because of home consumption of production, farm-supplied inputs, asset appreciation, etc.).

In the 1970s the average income of farm families approached, then exceeded, that of non-farm families. Increasingly, the farm problem was being defined by commentators as something other than low income levels. Concern has shifted to the variability of farm incomes rather than the absolute or relative level. This term used to describe this concern with variability is "cash flow". There are two aspects to the cash flow problem faced by farmers. One is the fact that a major portion of a farmer's returns has typically been in the form of a capital gain on his land. This return is realized only when the land is sold. Expenses, on the other hand, do not wait until the farmer sells his land. Thus, there is a divergence between the timing of income flows and cash expenses. A second aspect of the problem is the variability of earnings. A farmer has a large component of fixed costs which must be met if he is to retain his land. He also has variable costs that are incurred several months before he realizes a return. Furthermore, the level of his return is uncertain at the time expenses are incurred. In summary, cash flow problems develop because returns are variable and clustered near the end of the stream of returns while expenses are relatively evenly spaced throughout the period of land ownership.

In the early 1980s we have, however, seen a precipitous drop in farm income. The Detroit Free Press reported that farm incomes in Michigan would be 50 percent lower in 1981 than they were in 1980. The same source reported that 52 percent of Michigan farmers with loans from the Farmers Home Administration were delinquent in their loan payments in 1983.[1] It is an open debate whether low or variable incomes is the dominant issue. The question of concern here is the effect of revenue insurance on these farm income issues.

In Chapter 4 it was shown that revenue insurance would be expected to reduce the mean and variance of the revenue PDF. Under the assumptions employed in the model, this also means a fall in the mean and variance of farm incomes. Any other result would be implausible. If income increased when insurance was purchased, there would be no limit to a buyer's demand for insurance. An increase in a buyer's income also means the insurance company is disbursing more than it is collecting and this could not continue indefinitely without the seller going bankrupt. The conclusion is, therefore, that a revenue insurance program, if run on actuarial principles, is an ineffective and inappropriate means of increasing income levels within the farm population. On the other hand, revenue insurance is expected to reduce the variability of revenue.

Entry barriers are an important problem in American agriculture which are affected by cash flow problems. The major barrier to entry in the farm sector is the extremely high cost of starting up. In particular, many authors have discussed the problems arising from very high land prices. Raup found that between 1967 and 1977, agricultural land prices went up 100 percent with 80 percent of the increase occurring between 1972 and 1977. Land prices increased more in the Corn Belt, Northern Plains and mid-Atlantic states than elsewhere in the U.S.

Melichar shows that current and past land prices may be justified in terms of the total returns to that factor. However, these high prices are likely to lead to cash flow problems, large increases in debt, troubles for beginning farmers and an influx of wealthy investors from outside farming who, for a variety of reasons, are interested in acquiring farmland. Robison and Brake show that during inflationary periods, cash flow problems will exist when purchasing a nondepreciating asset, such as land, even if inflation is perfectly anticipated, if the debt has to be paid back in equal installments. The result is, as Robison and Brake say, with 100 percent financing, "outside income (their emphasis) equal to the first period's capital gain will be required to service the debt in the first year if only interest cost is repaid."[2] If beginning farmers have little or no outside income, this can be a formidable problem. According to Carter and Johnson capital gains as a percentage of farm production income increased from 20 percent in 1960 to 175 percent in 1975.

Lee and Rask and Harris and Nehring have constructed models to examine the bidding process for land in agriculture. Lee and Rask compared the maximum bid price for land in the Corn Belt under a variety of conditions. They found that regardless of the scenario, those buying whole farms of an economic size (ie. wealthy investors) and those adding to existing farms that were already of an economically viable size, could outbid new entrants and owners of small to moderate sized farms. Harris and Nehring examined the characteristics of buyers who could afford to make higher bid prices and concluded that no single investor is likely to match all criteria. However, safe assumptions (such as decreasing risk aversion over wealth and lower time preference rates for wealthy individuals) make it likely that wealthy investors will generally make higher bids for a given plot of land. The conclusion reached is that with high and rising land prices, beginning farmers have a difficult time competing for land that comes onto the market and, because of cash flow problems, have a difficult time keeping land they do acquire.

Revenue insurance will reduce the variability of returns and should, therefore, reduce the importance of this aspect of the cash flow problem. Variability of returns is particularly troublesome for young farmers. For example, if a young farmer has a poor revenue year early in the period of land ownership when he has little owner's equity, he may find it difficult to qualify for loans needed for his economic survival. By increasing the minimum level and decreasing the variability of returns, revenue insurance could reduce this problem for young farmers.

In addition, in Chapter 6 it was noted that younger farmers may have greater propensity to purchase revenue insurance. If this finding holds for the farm population as a whole, the consequences of this greater propensity to purchase revenue insurance could be important. For one thing, it would decrease the cash flow problems of this vulnerable group relative to the general farm population. In addition, with assurance of some minimum level of annual gross receipts, access to credit should be increased. Both of these results would be expected to improve the ability of younger farmers to acquire and hold land.

There are, however, two other factors that would be expected to have the opposite effect. First, purchasing revenue insurance will lower income. This would increase the need for off-farm sources of income in the early years of farming to cover cash costs. Secondly, stabilizing gross receipts in farming would increase the attractiveness of investments in agricultural land. This would be expected to drive bid prices even higher. As Harris says, "it is likely that any governmental policy designed to enhance or stabilize farm income will be inconsistent with our objective of stabilizing land prices."[3]

Further empirical work to quantify the degree to which young farmers are more likely to purchase crop insurance is needed. However, the results of the empirical work reported in Chapter 6 indicates that the desire to reduce the risk of a low revenue year may be the dominant factor in the revenue insurance purchase decision. It could be argued that the lower income level caused by purchase of a revenue insurance policy would be a price worth paying if this would significantly improve the farmer's ability to retain control over his largest asset, his land base. The historical record indicates that for whatever reasons, farmers have been willing to pay this price since farm incomes have tended to lag behind those of the non-farm population. The purchase of revenue insurance may simply be a different manifestation of this willingness. The impact of increased stability of returns on bid prices for land is a dynamic question which the models constructed are unable to address directly.

Instability in Agricultural Markets and Revenue Insurance

An issue closely related to low and variable incomes in agriculture is the problem of instability in agricultural markets. Instability in these markets affects the prices and quantities of agricultural products. This instability affects not only the earnings of farmers but other participants in the food system as well.

Few farm policy issues have received more attention than instability in commodity markets. There is not much argument that agricultural markets have been quite unstable, especially in the recent past. As Grennes, Johnson and Thursby point out, the real price of wheat trended downward almost continuously from 1946 through 1970. In the early 1970s, the price rose rapidly, reaching a post war peak in the winter of 1973/74. By 1977 prices had fallen to nearly the lowest price of the century, the 1932 price of $1.20 per bushel (real 1967 dollars). Harrington examines the variability of the index of prices received for all agricultural products, for all crops, for all livestock and various definitions of farm income. He calculates the coefficient of variation (σ^2/μ X 100) for these measures during three periods: 1955-1963, 1964 - 1971 and 1972 - 1978. For virtually every category the coefficient of variation increases monotonically as you approach the most recent period. Figure 7.1 illustrates the percentage

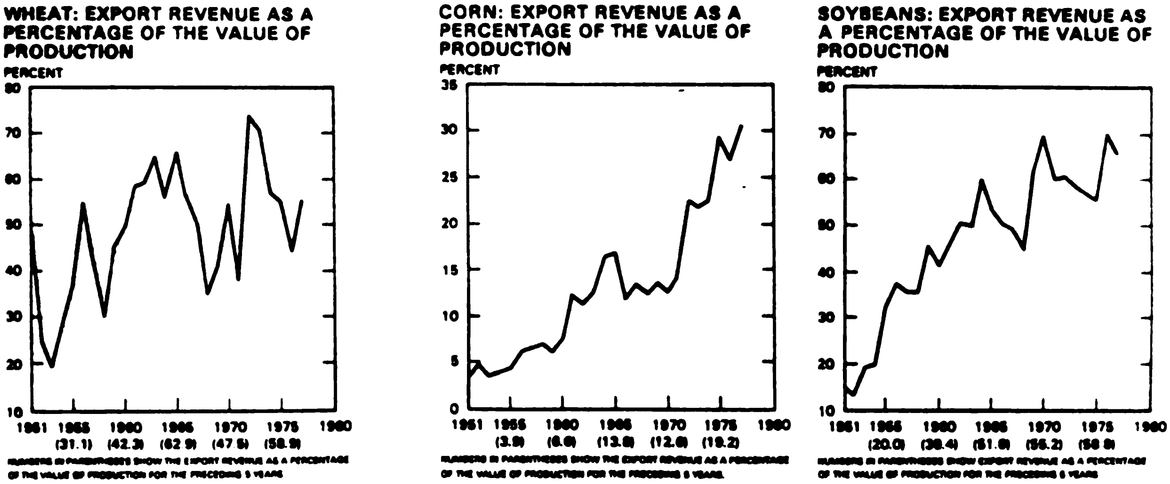

Figure 7.1: Export Revenue as a Percentage of the Value of Production for Wheat, Corn and Soybeans, 1951 - 1978(a)

a. Ronald L. Meekhoff, "Implications of Increased Reliance on International Markets", in <u>Structure Issues of American Agriculture</u>, U.S.D.A., ESCS, Ag. Econ Rpt. 438, pp 258-259.

of the value of production earned by exports for wheat, corn and soybeans for the period 1951 to 1978. The volatility of this experience is evident. As exports have become a more important part of farm sales, the variability of export earnings has had a greater influence on the revenue experience of the farming sector.

Instability in agriculture has many dimensions that recommend it as an issue for public policy. Many argue that there is a direct relationship between instability and farm bankruptcies.

Bankruptcies cause both economic and psychic losses. It is not the costless adjustment that economic theory would indicate. Lawyer's fees and other transactions costs associated with the bankruptcy procedure are incurred. There are also costs of moving, retraining and so on. There is a loss of the farmer's agricultural talents. There are costs borne by the farmer's creditors as well. Table 7.1, reproduced from Kauffman's work, indicates one of the costs associated with the hog cycle, unplanned refinancing of loans. The clear implication of Table 7.1 is that increasing leverage increases the likelihood of refinancing. Refinancing would be expected to occur when the market for hogs falls and would increase the lender's costs. There are, in addition, the psychic costs of losing the farm and the lifestyle associated with farming and with the need to adapt to a new occupation.

Table 7.1[a]: Effect of Leverage on Refinancing (Percent)

		More than 75% of Operating Capital Borrowed	
		Yes	No
Refinancing Required	Yes	56	44
	No	19	81

(a)Source: Kauffman, 1983. page 141

Even if there is not a direct connection between instability and bankruptcy, instability does call forth actions which entail opportunity costs. Instability rewards protective actions that may or may not be productive. For example, profitable investments may be foregone so the farmer (and his bank) can maintain a large credit reserve.

Furthermore, instability in agriculture produces secondary effects. Rural communities and agricultural supply industries are affected by changes in agricultural prosperity. For example, last year's Payment in Kind program, which paid farmers in grain to take their fields out of production, had a substantial impact on the economic health of the farm implement and agricultural chemical industries. Consumers are also affected by this instability, both directly, via the prices paid at the supermarket, and indirectly, by the effect on the cost of living allowance calculation used to index many wage agreements.

Finally, agricultural stabilization programs may be seen as attempts by the government to undo with its left hand what it has caused with its right. Seen in this way, price supports, the farm credit system, and other policies are counterweights to an overpriced dollar, high real rates of interest, grain embargoes and so on. Thus, if the government induces instability by some of its actions it is only "fair" that they attempt to undo some of the effects of those actions.

The ability of revenue insurance to reduce instability in agricultural markets depends upon the cause of the observed variability. Potential sources of agricultural instability discussed in the literature include the performance of the general economy, foreign trade, agricultural policy, depletion of grain reserves, misallocated resources, the industrialization of agriculture, the environment, technological change, and the structure of the food system. Some of these hypotheses will receive more extensive treatment in the discussion to follow.

The Business Cycle

Researchers in agricultural economics who have examined the importance of links between general macroeconomic conditions and conditions in agriculture include Schultz, Hathaway, Tweeten (1980b), Tweeten and Plaxico, Gardner(1981a), and Shepard and Collins. Schultz presents evidence that over the period 1911 - 1942 farm and non-farm net per capita incomes rose and fell together but the fluctuations in agriculture were much greater. One of his tables, indicating the magnitude of the fluctuations in the incomes of agricultural and non-agricultural households, is reproduced in Table 7.2 below. Schultz concluded that dependence upon an industrial economy subject to sharp reversals of fortune may be "the Achilles' heel of agriculture".[4]

Table 7.2 - Cyclical Movements in Per Capita Farm and Non-Farm Income(a)

Period(b)	Per Capita Net Income of Persons on Farms Percent Change from First to Last Year of Period	Per Capita Net Income of Persons Not on Farms Percent Change from First to Last Year of Period
1911 - 1919	+160	+88
1919 - 1921	-62	-18
1921 - 1929	+87	+22
1929 - 1932	-67	-52
1932 - 1937	+153	+59
1937 - 1938	-19	-7
1938 - 1943	+213	+101

a. T.W. Schultz, Agriculture in an Unstable Economy, McGraw Hill Book Co., New York, 1945, p. 214.
b. The periods were chosen on the basis of changes in direction of per capita income levels. Thus, 1929 represents a peak in per capita income growth and 1932 the bottom of a period of decline.

Hathaway, writing an update of Schultz' Agriculture in an Unstable Economy in the late 1950s, continued the theme of the importance of the performance of the non-farm economy for agriculture's well-being. He found that during periods of general economic recession, yields per acre fell, probably because farmers applied fewer units of variable inputs, especially purchased inputs. The decline in production resulted in falling farm incomes.

Instability in the economy as a determinant of farm income seems to have been a less dominant theme in the 1960s. Undoubtedly this was because of the relatively high level of performance of the economy during this period. But, with an increase in the volatility of macroeconomic performance in the 1970s and early 1980s, the literature is once again examining the link between the macro-economy and agriculture.

Given the long debate on this topic, it is interesting that there is little agreement as to its validity. Table 7.3, updates Table 7.2 and indicates that during the period from 1940 to 1981, the performance of the agricultural sector ceased, in a strict sense, to follow the non-agricultural sector. From 1940 through the early 1950s the pattern observed by Schultz continued to hold; the farm and non-farm sectors expand and contract together and the swings in the farming sector are wider. From 1954 through 1981 the non-agricultural sector experienced a period of continuous expansion of disposable income. The farm sector had a period of sustained growth from 1959 until 1973 but experienced several up and down cycles on either side of this growth period. Over the period 1954 to 1981, if the periodic down turns in the agricultural sector are ignored, the net increase in disposable income was greater for farmers than non-farmers. However, the fact that numerous cycles were experienced in farming while the non-farm economy continued to grow indicates that factors in addition to macroeconomic performance must be at work in determining the health of agriculture.

Table 7.3 - Cyclical Movements in Per Capita Farm and Non-farm Disposable Income (From All Sources)(a)

Period	Per Capita Disposable Income of Persons on Farms Percent Change from First to Last Year of Period	Period	Per Capita Disposable Income of Persons Not on Farms Percent Change from First to Last Year of Period
1940-1948	+265	1940-1948	+104
1948-1949	-16	1949-1949	-.15
1949-1951	+25	1949-1953	+24
1951-1955	-12	1953-1954	-.12
1955-1958	+22		
1958-1959	-6		
1959-1973	+383		
1973-1974	-5		
1974-1975	+7		
1975-1976	-7		
1976-1979	+75		
1979-1980	-12		
1980-1981	+17	1954-1981	+424

a. Disposable Income = Gross Farm Income less Production Expenses less Net Income of Non-resident Operators plus Wages, Salaries and Other Income of Farm Residents.

Source: "Economic Indicators of the Farm Sector: Income and Balance Sheet Statistics, 1981", Table 65, U.S.D.A., ECIFS 1-1, Washington, D.C. 1982, page 89.

B. Gardner (1981a), Firch and Shepard and Collins all estimated regression equations in an attempt to identify the various components of commodity market instability. Firch found the business cycle to be the most important variable over the period from 1966 to 1975. Both Gardner and Firch downplay the importance of macroeconomic conditions. They feel that with the many automatic stabilizers built into our economy since the early 1960s, the business cycle should be of diminished importance in explaining changing farm incomes. Firch believes that the business cycle variable in his equation is picking up some of the variability of foreign demand which accounts for its significance.

Shepard and Collins use business failures in the non-farm economy as a proxy for macroeconomic conditions. They report that this variable was positively related to farm failures and conclude that the economic well being of agriculture is dependent upon macroeconomic conditions. The exact relationship between farm and non-farm conditions is unclear. It could be, as Firch argued, that non-farm failures are the result of the variability induced by changes in foreign trade.

However, the general economy is not only the market for most agricultural output, is is also a major source of employment for farm families. The degree to which farm families are dependent upon off-farm sources of income is illustrated in Table 7.4. The numbers in Table 7.4 indicate that an amazing transition has taken place in farming, especially for the two middle groups. Even for the largest group of farms, off-farm income is approaching one-fifth of total gross income. Because of the increased importance of off-farm earnings and because of the increased volatility of the macro-economy, Breimeyer feels we are entering the "macro phase" of agricultural policy". Central to this phase is the premise that what is good for the economy as a whole is good for agriculture. This is quite similar to the view expressed by Schultz and Hathaway.

Table 7.4 - Income from Off-farm Sources as a Percentage of Total Income for Four Sizes of Farms, (Classes Based on Value of Sales).

Year	$100,000+	$40,000-$99,999	$10,000-$39,999	$9,999-
1969	7.2	15.7	31.1	93.5
1970	8.2	16.2	32.7	95.6
1971	8.2	17.4	37.1	99.5
1972	7.5	16.1	37.1	98.0
1973	6.5	16.0	42.8	96.9
1974	7.5	21.4	50.2	101.3
1975	7.6	23.9	58.0	103.5
1976	9.0	28.0	66.3	105.5
1977	10.4	32.0	73.7	107.5
1978	10.0	29.7	71.2	104.2
1979	12.5	38.0	82.4	103.5
1980	14.3	50.4	95.2	104.5
1981	17.1	69.1	108.5(a)	105.5

SOURCE: "Economic Indicators of the Farm Sector: Income and Balance Sheet Statistics, 1981", Table 57, U.S.D.A. ECIFS 1-1, Washington, D.C., 1982.

(a) A figure greater than 100 implies that money was lost in the farm operation.

Tweeten (1980b) argues that the avenue by which instability in the macro-economy is transmitted to the farm economy is the inflation rate. In estimating the relationships between aggregate supply and demand and farm-level supply and demand, he found all functions except farm level demand to be homogeneous of degree zero. He found that farm level supply adjusted to inflation more rapidly than farm-level demand. Therefore, prices paid by farmers tended to increase more rapidly than other prices in the system and resulted in a cost-price squeeze on the producer. Another viewpoint is presented by Lamm and Westcott. Using a three stage least squares analysis, they tested the hypotheses that price increases at the farm level are rapidly passed through to the retail level and that farm level prices determine retail prices as part of a price "mark-up" pricing system.

Their results indicate that virtually all price increases experienced by farmers are passed on to the retail level within three months, with most adjustments being made in the first month. One quarter was the longest lag that was significant in their analysis. They present evidence to support their hypothesis about the unidirectionality of influence. If this were true the implication would be that farm prices and farm costs adjust over time at roughly the same rate. If prices paid and received did in fact move in harmony, farm incomes would be expected to remain relatively contant. This is not consistent with history.

In summary, the discussion of the importance of the business cycle in determining the well-being of the farm sector is inconclusive. The empirical work done to date has not resolved this issue satisfactorily though the direct relationship between the economy as a whole and the farming sector, as hypothesized by Schultz, is not as evident as it was in earlier periods. Regardless of the degree to which general economic conditions determine the well-being of the agricultural sector, it is unlikely that revenue insurance will alter the relationship. Revenue insurance is unlikely to be a major factor in determining the course of the business cycle since the agricultural sector is but one small component of the entire economy. Revenue insurance would be expected to reduce the impact on the farm population of instability transmitted from the general economy.

Foreign Trade

While foreign trade is indisputably a portion of the macro-economy, the policy response to foreign trade induced instability will differ from the response if domestic instability is the villain. For this reason it is useful to separate the discussion of the impact of foreign trade on instability in agriculture from the discussion of broader macroeconomic factors.

From the end of World War Two until the late 1960s, U.S. agricultural exports were hampered by a domestic agricultural policy that maintained domestic prices above the world price and used trade barriers to protect the farming sector. Many of our exports during this period required export subsidies to find a market. Schuh (1974) argues that another major factor in the relatively poor showing of our exports during this period was an overvalued dollar. He argues that agricultural exports increased over the 1950s and 1960s mainly because technological change was able to counterbalance the overvalued dollar. With the devaluations of 1971 and 1973 and the adoption of floating exchange rates in April 1973, the dollar should have ceased to be overvalued. It is probably not coincidental that U.S. exports expanded dramatically over the course of the 1970s. From 1950 to 1972 the compounded annual growth rate of the value of agricultural exports was 7.0 percent. From 1972 to 1980 this growth rate was 22 percent.[5] By 1980 one out of every 3.5 acres planted was for export markets[6]. According to Houck (1979) soybeans and feedgrains accounted for 2/3 of the value of our exports in 1978. The U.S. exported "40 percent of the wheat, 70 percent of the corn and nearly 80 percent of the soybeans" that entered international trade in the late 1970s.[7] It is highly probable that the trend reversals that occurred in farm income in the 1970s, (See Table 7.3 on page 166), are the result of this increased reliance on foreign trade.

D. Gale Johnson (1982) attributes growth of U.S. exports during the 1970s to the devaluation of the dollar, increased imports by the centrally planned economies and increasing incomes of middle income countries such as OPEC nations and some Asian and Latin American countries.

Returns from exports were quite volatile in the 1970s as is indicated in Figure 7.1. Three variables are typically used to explain the variation noted in these graphs. D. Gale Johnson (1975) hypothesizes that a portion of the observed variability is explained by improved control of trade on the part of some countries, especially the European Economic Community (EEC), the U.S.S.R. and its East European allies, and China. The isolation of these countries from most of the adjustment costs associated with international trade is significant because, according to Johnson's estimates, they account for roughly one-half of the total amount of grain traded in the international market. In support of this hypothesis Steele estimated that during the period from 1963 to 1975, 80 percent of the deviation from trends in world wheat exports are explained by changes in the importation levels of the Soviet Union and 90 percent by changes in the importation levels of all centrally planned economies. Grennes, Johnson and Thursby constructed a simulation model to estimate the price effects in major importing and exporting countries that would result from a ten percent increase in the imports of the U.S.S.R., given current "restrictive" trade policies. Their results indicate that wheat prices in the U.S., Canada and Australia, the major exporting nations, would increase by 17.5 percent, 5.7 percent, and 7.0 percent respectively. The EEC, with its protective tariffs and variable levies, would experience a price increase of only 3.5 percent.

A second major source of variability in international agricultural commodity markets is the exchange rate. Empirical investigations into the importance of exchange rates have been done by Chambers and Just, Johnson, Grennes and Thursby and Collins, Meyers and Bedahl. The most interesting result noted by these studies is that the effects of exchange rate changes on international trade, are crop specific. That is, the impact of exchange rate movements on wheat may be dissimilar to the effect on cotton. Chambers and Just found that exchange rate changes were extremely successful in explaining short term variations in wheat and soybean exports, and only slightly less successful with respect to corn. They found that inventories of corn and wheat were very sensitive to exchange rate movements while soybeans were more sensitive to changes in domestic consumption. In estimating the elasticities of these three crops with respect to the exchange rate, they found that short term export elasticities for wheat and corn were greater than one, in absolute value, but less than one for soybeans. They conclude that "exchange rate fluctuations (have) had a significant real impact on agricultural markets by altering the volume of exports and the relative split between exports and domestic use" with respect to wheat, corn and soybeans.[8]

Johnson, Grennes and Thursby built a model of world wheat trade which differentiates wheat by point of origin to test the hypothesis that exchange rate changes could explain price increases for wheat in 1973/74. They failed to find support for the hypothesis. In commenting upon this result, Chambers and Just note that this static result actually conforms to their expectations in that they found the long run exchange rate elasticity of price to be less than one for wheat.

Finally, Collins, Meyers and Bedahl note that exchange rate movements are rarely, if ever, consistent across currencies. For example, through the 1970s the dollar depreciated against most currencies in Western Europe but appreciated against many of the currencies of less developed countries. Since the mix of products purchased by developed and less developed countries is different, with LDCs importing relatively more wheat and cotton while DCs purchase mainly corn and soybeans, different exchange rate impacts should be expected. They found that exchange rate changes could explain a relatively small portion of real price changes for wheat, corn or soybeans but a large portion for cotton. They concluded that, except in special cases, exchange rate movements are unlikely to be the driving force behind changes in commodity prices in the U.S. Again, this result does not necessarily conflict with the findings of Chambers and Just since it refers to a longer term impact.

A third source of agricultural export instability of increasing concern is the issue of non-tariff barriers (NTBs). As Hillman points out, NTBs are an especially difficult issue to analyze because there is little by which you can evaluate them. They tend to be more administrative in nature and hence are more removed from the public eye than are tariffs. Many NTBs can be implemented by the executive branch without a specific mandate from the legislative branch of government. Hence, NTBs can be instituted, changed, rescinded or otherwise amended with greater flexibility, some might say capriciousness, than tariffs which often require legislative approval for amendments and are subject to international agreements such as the Generalized Agreement on Tariffs and Taxes. In addition, even if NTBs do result from a law or proclamation that specifies their function, the letter of the law is much less important than how it is carried out. Needless to say, NTBs are a very thorny issue in trade negotiations.

In summary, economic theory has long touted the benefits of trade. A world with free trade was suppose to be the best of all possible worlds since both parties to a trade are made better off. The volatility of agricultural markets during our recent past has caused many to appreciate the costs as well as the benefits of trade.[9] In the U.S. trade fluctuations have contributed to variations in farm income. I believe that a substantial portion of the observed variability in export markets arises from the inability to anticipate political decisions which affect them. When the Soviet wheat crop failed for two consecutive years in the early 1970s, the market had no way of knowing that the Kremlin would reverse the long established practice of slaughtering livestock to reduce the grain deficit and instead go onto the world market to satisfy their requirements. Likewise, when the Soviet Union invaded Afganistan, the markets could not have known that President Carter would place an embargo on wheat sales to the U.S.S.R. The markets cannot anticipate the imposition of a NTB or an importation quota. If markets cannot predict these types of events, and such events result in instability in commodity markets, it is difficult to imagine that revenue insurance could do much to reduce this source of instability. One of the primary selling points of a revenue insurance program is its ability to transmit market signals which tell the farmer to expand or contract production. But agriculture is based on biological processes which cannot be speeded up. Adjustments to new market conditions take time. If political decisions profoundly affect the terms of trade and the market is unable to transmit signals to farmers in advance of these actions, revenue insurance will not enhance the ability of farmers to make adjustments reducing the magnitude of changes in market conditions wrought by the political decisions. As was the case with instability generated by changes in the general economy, the principle effect of revenue insurance on instability caused by international markets will be to reduce the impact of this instability on the welfare of the farm population.

The Industrialization of Agriculture

Carter and Johnson feel that the industrialization of agriculture, with its increased market orientation, is the most significant change in American agriculture since the advent of the tractor. During this process agriculture went from a situation in which the farming unit was extremely self-reliant to one in which it purchased most of its needs. Farmers began purchasing electricity from the Rural Electrification Administration, horsepower from John Deere or others, seeds from Pioneer, Dekalb and others, transportation from General Motors, desserts from Pepperidge Farms, credit from the Production Credit Association and labor from the United Farm Workers.

Harrington calculated production expenses as a percentage of gross farm income for selected years between 1935 and 1981. In 1935, production expenses were 53 percent of gross income, by 1981 they had grown to 88 percent for the average farm. Farms with sales of greater than $100,000 tended to have a higher ratio of expenses to gross sales than did smaller farms. Harrington believes that this increased dependence upon and commitments to outside sources of inputs makes a farm less flexible and more sensitive to exogenous shocks. In the past, during hard times and when starting out in farming, farm families survived by cutting back on cash expenses and using greater discretion in how they used their inputs. They tightened their belts. Today, there are fewer notches left in the belt. Farmers have less control over their business. This greater exposure to exogenous shocks, when combined with the increased dependence of the farm population on off-farm sources of income, seems to lend support to hypotheses discussed earlier which stressed the importance of the business cycle or foreign trade in determining the economic health of the food system.

One result of the industrialization of agriculture has been an increased dependence upon markets which are oligopolistic in nature (a possible basis for Tweeten's cost-price squeeze hypothesis). Another result is that fewer people see agriculture as a unique sector of the economy. Prior to the integration of agriculture into the broader economy, policy makers routinely gave agriculture special consideration. Agriculture was endowed with a set of institutions designed to cope with its special requirements (the federal farm credit system, land grant universities, the U.S.D.A. and so on). Legislation routinely exempted farmers from policies felt to be unduly burdensome on them (minimum wage, child labor laws, the draft, accrual accounting, anti-trust, etc). Most of these special provisions continue to exist but there is also a growing current of protest from non-agricultural sectors of the economy about the special treatment. Another indication of the diminished sympathy for the idea that agriculture is unique is the proliferation of voices involved in agricultural policy and the way in which the agenda for policy debate is determined. Far from being cognizant of any unique characteristics of agriculture, policy debates are, according to Infanger et. al., now determined by budgetary considerations completely divorced from any policy goals.

Finally, industrialization has increased the degree of specialization in farming. As farmers have expanded the size of their operation in an effort to take advantage of economies of size , they become more reliant on the performance of a single market. This would be expected to increase the variability of revenue earned.

Revenue insurance is yet another off-farm input and an additional cash expense. However, by assuring a given minimum return, revenue insurance might counteract some of the increased vulnerability caused by the industrialization process. This is a variant of the earlier discussion regarding cash flow problems. Revenue insurance would be expected to enhance the economic survivability of the farm by several means. First, insuring a minimum level of income increases the likelihood that cash expenses will be met. Second, the ability of farmers to plan investments and obtain credit should be enhanced by a revenue insurance program. Finally, while a specialized farm would still be dependent upon the long term health of the market for its output, the impact of short term deviations from trends would be reduced.

Chronic Excess Supply

Another explanation of instability focuses on the volatility of supply. Supplies of agricultural commodities vary over time for a variety of reasons: cycles, environmental factors, public policy changes and so on. If demand is relatively stable, changes in supplies will dramatically alter the returns to agricultural commodities since most face relatively inelastic demand curves.

Sandmo, in a theoretical consideration of production under uncertainty, concluded that if uncertainty is reduced, production will expand. This would seem to lead to the conclusion that revenue insurance might exacerbate the problem of surpluses. This is likely to be a short term result only since expansion of production would, ceteris paribus, be expected to reduce the price received for the commodity that is in surplus. The response should be a reduction in output of that commodity. By increasing the strength of market signals, revenue insurance should reduce the problem of chronic oversupply. These adjustments will, of course, take time and will entail significant costs for the farm population.

Surpluses can also be of a more acute nature, as in the case of cycles. It has been suggested that revenue insurance would increase the potential for planning by farmers. To the extent that this occurs, coordination in the food system would be expected to improve and cycles to diminish. The validity of this hypothesis is an empirical issue.

Summary and Conclusions

This chapter discussed two problems facing agriculture, examined competing hypotheses about the causes of these problems and the effect a revenue insurance policy may have on these problems. The first issue examined was entry barriers in agriculture. The major cause of barriers to entry in agriculture, high start-up costs, is associated with high land prices. Evidence was presented indicating that land prices are high because returns to investments (in the form of the value of agricultural output, tax advantages and capital gains) are high. Because returns and expenses occur at radically different points in the investment period, outside income is necessary in the early years of a land purchase. The group least able to compete for land is likely to be young farmers trying to enter farming. The impact of revenue insurance on the issue of entry barriers is ambiguous though there is evidence indicating that revenue insurance might reduce the problem.

Instability in agricultural markets was discussed in some depth. My conclusions are that macroeconomic conditions and foreign trade in particular, have increased the degree of instability witnessed in agricultural markets. With bigness and specialization comes increased reliance upon off-farm inputs and upon the performance of a single market. The result is an increased vulnerability to exogenous shocks. The ability of revenue insurance to alter the conditions underlying instability is limited. It will, however, have an important role in reducing the costs associated with instability. This is of particular importance at the level of the individual farm. It bears repeating that the principle of insurance is to take a small amount of money from a large group so that the losses of a small subset can be compensated. Revenue insurance would reduce the impact of market instability on the welfare of the farm population. It would not cure the disease but would treat the symptoms. To the extent that instability is caused by inability to plan investment decisions, revenue insurance should enhance planning potential and hence reduce the instability observed in commodity markets.

In the closing chapter, the conclusions reached will be summarized, recommendations concerning the feasibility of revenue insurance made and future directions of research noted.

1. See the Detroit Free Press, September 23, 1982 and April 3, 1983.

2. Robison, Lindon and John R. Brake, Dec. 1980, page 132.

3. Harris, Duane G., 1977, page 1106.

4. Schultz, T.W., 1945, page 128.

5. O'Brien, Patrick M., 1981, page 13.

6. O'Brien, ibid page 3.

7. McCalla, Alex F. and Andrew Schmitz, 1979, page 1022.

8. Chambers, Robert G. and Richard E. Just, 1981, page 44.

9. See Warley for a brief discussion of this view of trade.

Chapter 8

Summary, Conclusions and Issues for Further Research

This chapter summarizes the results of earlier chapters and evaluates of the strengths and weaknesses of the revenue insurance program. Finally, issues within this topic area and methodological questions needing further consideration will be addressed.

Summary

In Chapter 2 the historical records of a number of public insurance programs were examined. Successful programs tend to be based on the individual's personal experience as directly as possible, settle claims promptly, have easily understood provisions and have few close substitutes. The coverage must also protect a variable of concern at a sufficiently high level to gain and hold the interest of the buyer.

Based on these characteristics a revenue insurance program was proposed. This program would offer coverage based on an individual's gross farm receipts from all farming activities in a single crop cycle. Coverage levels would be a percentage of average returns over a base period (ten years) and would be adjusted over time to account for inflation and changing risk structures. Policies would be sold and serviced by private insurance companies with reinsurance services offered by the federal government. Premiums would at least cover indemnities.

In the third chapter the economic and psychological approaches to the study of insurance were examined. Economists have improved our understanding of the causes of adverse selection, moral hazard, the importance of information to sellers (in terms of types required and the timing of acquisition) and the importance of considering more than observed behavior in determining the risk attitudes of individuals.

Psychologists have provided valuable insights into human behavior in uncertain environments. Psychologists have, for example, highlighted the inclination of consumers to buy insurance for high probability-low cost risks, the importance of framing and the limited ability of people to process and utilize statistical information in a dynamic context.

Economists have been criticized because empirical work has provided convincing evidence that the assumptions about behavior frequently employed by economists don't bear a close resemblance to actual consumer behavior. Psychologists have been criticized because it is difficult to falsify, in the sense of Popper, their propositions (eg. Prospect Theory). Both schools, though imperfect, have provided insights that should prove useful to a policy designer contemplating a revenue insurance program.

In Chapters 4 and 5 mean variance models of demand and supply were developed for a revenue insurance market. The results of these models indicated that demand for insurance will increase as a buyer becomes more risk averse, as the loading factor used to calculate his premium falls or if there is an increase in the size and likelihood of receiving an indemnity. The seller's side of the market is more complex but it was concluded that the seller will increase the level of coverage offered if his clients become more risk averse, if he becomes less risk averse or if the correlation between his clients' outcomes decreases. The most important conclusion about this market was the strict interdependence between the two sides of the market. Because of this interdependence the actions of either the seller or the buyer cannot be considered in isolation from the other.

Chapter 6 summarized the empirical phase of the study. Support for the theoretical models of the two previous chapters was found. The field work indicated revenue insurance might be less expensive to operate, in terms of indemnity payments, than anticipated. Furthermore, relatively high levels of participation could be attained at premiums that would more than cover indemnities. This is an indication of the viability of the program. The appeal of revenue insurance does not appear to be limited to any single class of farms (classified by number of acres).

Finally, in chapter seven the role of revenue insurance in farm policy was examined. Revenue insurance is not a panacea for the diverse challenges facing U.S. agriculture. Two examples of current farm problems, entry barriers and unstable commodity markets, were discussed. The conclusion reached is that revenue insurance will reduce the impact of these problems as experienced by the individual farm, but will not eliminate these issues.

An Evaluation of Revenue Insurance

Many positive characteristics of a revenue insurance program were discussed in this thesis. First, it offers coverage on a variable that is of greater direct interest to farmers that do current programs.

Second, the emprirical investigation indicated that the cost of providing this type of protection could be less than anticipated from the point of view of the farmer and the government. Annual average indemnities received were less than $8.00 per acre for all farms in the sample. In addition, farmers indicated a willingness to pay a premium in excess of what would be needed for actuarial fairness meaning a portion of the administrative costs of the program could be covered by premiums collected.

A third aspect of the program that is encouraging is that it seems to attract participants from farms of many different sizes. In addition, younger farmers may have a greater propensity to purchase revenue insurance. If revenue insurance increases the ability of a farm to weather bad economic times, the higher propensity of younger farmers to purchase insurance could have important structural consequences for agriculture.

The revenue insurance program has the very attractive feature of linking management decisions and program benefits. A program such as deficiency payments or even the Grain Stabilization Program of Western Canada have an important weakness: the actions of the individual farmer have relatively little impact on the amount of the benefits received or the cost of protection. For example, a deficiency payment is received by a participating farmer if he has complied with the planting, tending and harvesting requirements set forth in the program and the price for his crop is below a pre-specified level during the first five-months of the marketing season. His past management decisions will be partially reflected in the base upon which his benefits are calculated. But, the amount per bushel he receives is based less on his actions than upon the aggregate actions of all farmers producing his crop. In addition, each participant pays the same percentage cost to participate, regardless of farm size or riskiness of production. Thus, if a ten percent set-aside is required, every participant takes ten percent of his land base out of production. A revenue insurance program, as discussed in this thesis, would tie both benefits and costs to management decisions of the individual farmer client. This would offer the possibility of sending powerful market signals, in the form of a higher premium or lower insured level, to farmers whose management decisions are out of line with prevailing market conditions.

Of course, the program is not without its drawbacks. One problem is the large amount of disinterest in the program indicated by the high proportion of farmers who refused to participate in the study. Even those who did participate voiced a great deal of skepticism about the program. A good deal of the negative response to the idea of revenue came from the impression that revenue insurance would remove the "right to fail" from farming. Many seemed to think of the program as a form of agrarian welfare that would undermine the moral fiber of rural America.

Another issue concerns the equity of a revenue insurance program. In Chapter 7 it was argued that a significant portion of the variability in agricultural markets comes from fluctuations in foreign trade and general economic conditions. If the farmer is not in any way responsible for a large part of the instability he experiences, yet is asked to pay a premium covering all the costs associated with this variability, there is a question about the justness of this solution.

As noted by Viscusi in Chapter 3, it is only by changing the insurance premium that insurance can indirectly affect the causes of risk. Since many of the factors which determine the riskiness of a farmer's revenue experience are beyond his control and not affected by changes in his behavior, this may lessen the amount of market information that can be transmitted by the insurance premium. Specifically, the management decisions of a single farmer in Iowa will have little influence on how Washington determines monetary, fiscal or trade policy and even less over similar decisions taken in the capitols of our major trading partners. Yet, these exogenous decisions will affect the level and variability of his earnings and, thereby, affect his insurance costs and coverage levels.

There is also a question about the longer term impact of revenue insurance on bid prices for agricultural land. If revenue insurance increases the stability of returns in agriculture, this might make investments in agricultural land more attractive. In short, the dynamic response of the system to revenue insurance could exacerbate the problem of entry barriers.

Finally, a number of adminstrative issues were raised but left unanswered. The most vexing of these questions is how to deal with beginning farmers and those who undertake a major reorganization of their operation. In both cases the data required to establish an insurance program based on the client's characteristics is lacking.

My bottom line on revenue insurance is that it is a promising program that contains some very challenging design problems. It is a program that merits serious consideration and further study.

Methodological Issues

There are three fairly obvious methodological issues arising from this study: data issues, testing the reformulated model and broadening the empirical base. All insurance programs are heavily dependent upon an accurate data base. It is from such a base that actuarial tables are constructed. This data base does not exist for a revenue insurance program. Part of the reason for this lies in the fact that the data needed, revenue earned from each crop cycle, frequently are not kept by farmers. A second part of the problem is that where they do exist, a significant proportion of farmers would be reluctant to divulge such data. Data collection will be difficult. On the one hand, this seems to be an insurmountable obstacle to implementation of a revenue insurance program. This assessment is modified somewhat by two considerations. First, data of equal or greater sensitivity and detail are routinely demanded and received by financial institutions which deal with farmers. Coordination between bankers and revenue insurance sellers would seem to offer substantial benefits to both parties. The second consideration is the communications revolution, as represented by the personal computer, that is progressing through the farming community. If, as is likely, home computers become as prevalent on the farms of the future as four-wheel drive tractors are on the farms of today, the maintenance, storage, retrieval and transmission of farm records will be greatly facilitated. The data problems may be overstated.

In the meantime, tax records, though a poor substitute, might provide sufficient data for inauguration of the program. Availability is still an issue with tax records. If the program is begun with tax data, it should be understood that after each year of operation a year of tax based data would be removed from the data base and a year of crop cycle data added. Less than optimal performance of the program might be expected until a good data base is developed.

The model developed in the empirical chapter needs additional field testing. The tests to which it was put in this dissertation were inadequate for the obvious reasons that direct farmer participation was not involved and the sample size was too small. It would be foolhardy to launch a major new policy on the basis of the results from fifteen or twenty farms. A broader sample would provide a better test of the model, better data from which to draw aggregate results and more information about particular portions of the farm population (eg. young farmers) about whom we have special interests.

Aggregate results might be obtained without more fieldwork in the following way. A number of studies have been done on the risk aversion coefficients of farmers. In addition to this study, King, Love, Carman and Cochran all did this type of research while at Michigan State University. There is a great deal of consistency in their results, leading to the conclusion that there is a fairly stable distribution of attitudes toward risk in the farming population of Michigan. A PDF over risk aversion coefficients could be constructed from the work cited above. This could be combined, via a Monte Carlo routine, with data from Michigan State University's farm record-keeping program, Telfarm, and the models developed in this thesis to generate premium projections for a much broader sample of farms. In addition, Telfarm records have data on inventory changes, so a much better picture of the crop cycle earning record of these farms could be achieved than was possible with tax-based data. To the extent that these farms are representative of farms in the U.S. and the distribution of risk aversion coefficients is representative of risk attitudes of farmers in general, valuable insights into the functioning of a revenue insurance program could be gained at relatively little additional cost.

Revenue Insurance Program Issues

In the final analysis every model is a gross simplification of reality. The degree to which it captures essential elements of behavior will determine its usefulness. There is no substitute for experience with a program, however, in determining crucial performance characteristics. Models such as those constructed in this work, help focus attention on aspects of likely importance but, as we have seen, they often raise as many issues as they answer. The task force commissioned to study revenue insurance suggested implementation of a three-year revenue insurance pilot program. While a three year program for insurance is somewhat of a contradiction of the philosophy of insurance, which depends upon long run probabilities for its livelihood, a pilot program could be a very useful experiment. It might answer some of the behavioral issues raised in this thesis. It could also help determine the acceptability of this approach to the farm population.

The ultimate cost and effectiveness of a revenue insurance program depends upon the details of the institutional design. In particular, the existence of other government programs, such as the current commodity programs, will profoundly influence the operation of a revenue insurance program. Part of the reason for the relatively stable revenue records of farmers is the existence of commodity programs during the base period. For participants in these programs they provided a means of achieving price insurance. For non-participants, target prices also helped stabilize prices by providing a point of resistance below which market prices could fall only with difficulty. If revenue insurance is implemented as a substitute for these other programs, an increase in the degree of variability in agricultural markets would be expected. The extent of increase is difficult to determine and is a question the pilot program would be incapable of addressing.

In conclusion, there are aspects of the program that some people will find appealing. Other people will find those same aspects unappealing. Whether revenue insurance could serve a useful role in the bundle of programs used in agricultural policy will, like all policies, depend as much upon the wisdom of the person designing the program as upon the inherent worth of the idea. There are many uncertainties associated with any idea that will restructure property rights. One result of this was noted by Machiavelli,[1]

> "There is nothing more difficult to arrange, more doubtful of success and more dangerous to carry through than to initiate a new order of things. . . Men are generally incredulous never really trusting new things unless they have tested them by experience."

Machiavelli's conclusion has particular relevance for revenue insurance. There are powerful interests likely to be opposed to the idea while prospective proponents are dispersed and made mute by the uncertainties of a new program. The prognosis for implementation of a revenue insurance program is not good, at least in the short run. In view of the problems facing agriculture, however, it is not an idea that can or should be abandoned.

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1. From The Prince as quoted by Mancur Olsen, 1983, page 58.

APPENDICES

APPENDIX 1

Properties of the truncated mean:

Given that the truncated mean is defined as:

$$\mu^* = a\mu P + Y_2 - \psi(a\mu P - Y_1) - C$$

(1) $$d\mu^*/da = (1 - \psi)(\mu P + am(\partial P/\partial a) + (\partial Y_2/\partial a) + \psi(\partial Y_1/\partial a)$$

but $$\partial P/\partial a = \mu f(a\mu)$$

and $$\partial Y_2/\partial a = -a\mu^2 f(a\mu)$$

and $$\partial Y_1/\partial a = a\mu^2 f(a\mu)$$

so $$d\mu^*/da = \mu P(1 - P) < 0$$

(2) $$d\mu^*/dY_2 = aP(1 - \psi)(\partial\mu/\partial Y_2) - \partial Y_1/\partial Y_2) + 1 + (\partial P/\partial Y_2)(a\mu(1 - \psi)$$

$$d\mu^*/dY_2 \quad 0$$

but if $dP/dY_1 \leq 0$

and $d\mu/dY_1 = 0$

then $d\mu^*/dY > 0$

(3) $$d\mu^*/d\psi = Y_1 - a\mu P < 0$$

(4) $$d\mu^*/d\mu = (1 - \psi)a(P + \mu(\partial P/\partial\mu) + \partial Y_2/\partial\mu + \psi\partial Y_1/\partial\mu$$
$$= aP(1 - \psi) < 0$$

(5) $$d\mu^*/dC = -1 < 0$$

Properties of the truncated variance:

Given that the variance is defined as:

$$\sigma^{*2} = (a\mu)^2P(1 - P) + \sigma^2_2 + \mu^2(1 - P) - Y^2_2 - 2a\mu Y_2 P_2$$

(6) $$d\sigma^{*2}/da = (dY^2_2/da) - \mu^2(dP/da) + 2a\mu^2P(1 - P) + \mu^2(dP/da)$$

$$+ (a\mu)^2(1-2P)dP/da - d(Y_2)^2/da - 2\mu Y_2 P - 2a\mu P(dY_2/da)$$

$$- 2a\mu Y_2 (dP/da)$$

but $$dY^2_2/da = -(a\mu)^2 f(a\mu)(\mu)$$

and $$d(Y_2)^2/da = 2Y_2(-a\mu^2 f(a\mu))$$

and, dY_2/da and dP/da are as previously defined.

Therefore,

$$d\sigma^{*2}/da = 2\mu P \int_{a\mu}^{+\infty} a\mu - Y)f(Y)dY < 0$$

(7) $$d\sigma^{*2}/dY_2 = \partial E_2(Y^2)/\partial Y_2) + (a\mu)^2(1 - 2P)(\partial P/\partial Y_2) +$$

$$2a\mu^2P(1 - P)(\partial P/\partial Y_2) - 2Y_2 - 2a[\mu P + Y_2 P(\partial\mu/\partial Y_2) +$$

$$\mu Y_2 (\partial P/\partial Y_2) \quad 0$$

(8) $$d\sigma^2/d\mu = 2a\mu^2P(1 - P) + (a\mu)^2(1 - 2P)(\partial P/\partial\mu) - \partial Y^2_2/\mu +$$

$$\partial E_2{}_2(Y^2)/\partial\mu - 2a(Y_2 P + \mu Y_2 (\partial P/\partial\mu) + \mu P(\partial Y_2/\partial\mu))$$

$$= 2aP(a\mu(1 - P) - Y_2) < 0$$

APPENDIX 2

Since

$$dCE = 0 = 1 - \varphi - \lambda(a\mu(1 - P) - Y_2)$$

We can determine the relationships between the optimal coverage ratio and the other variables in the model by taking the total differential of this first order condition with respect to the coverage ratio and the other parameters.

<u>Properties of the Optimal Level of Coverage for a Risk Averse Decision Maker</u>

(1) $d^2CE = 0 = [-\lambda\mu(1 - P)]da + [-1]d\varphi$

so $(da/d\varphi) = 1/(-\lambda\mu(1 - P)) < 0$

(2) $d^2CE = 0 = [-\lambda\mu(1 - P)]da + [-(a\mu(1 - P) - Y_2)]d\lambda$

so $(da/d\lambda) = (a\mu(1 - P) - Y_2)/(-\lambda\mu(1 - P)) > 0$

(3) $d^2CE = 0 = [-\lambda\mu(1-P)]da + [(\partial\lambda/\partial\mu)(a\mu(1-P) - Y_2) - \lambda(a(1-P))]d\mu$

if $(\partial\lambda/\partial\mu) \le 0$ then $(da/d\mu) < 0$

if $(\partial\lambda/\partial\mu) > 0$ then $(da/d\mu) \quad 0$

(4) $d^2CE = 0 = [-\lambda\mu(1-P)]da + [-\{(\partial\lambda/\partial Y_2)(a\mu(1 - P) - Y_2) +$

$\lambda(a(\partial\mu/\partial Y_2)(1 - P) - a\mu(\partial P/\partial Y_2) - 1)\}]dY_2$

so

$$(da/dY_2) = [(\partial\lambda/\partial Y_2)(a\mu(1 - P) - Y_2) + \lambda(a(\partial\mu/\partial Y_2)(1 - P) - a\mu(\partial P/\partial Y_2) - 1)]/[-\lambda\mu(1-P)] \quad 0$$

APPENDIX 3

As noted in the text of this chapter, only substitution effects on optimal levels of insurance coverage will be considered. When income effects are added most of the results are ambiguous. Considering only substitution effects, the first order condition (FOC) for the optimal coverage ratio offered by the seller is:

$$dCE^S/da = 0 = [\mu(Y_2 P - 2a\mu P(1 - P)) + Y_1 (1 - P))](\Sigma_{i=1}^{n} \alpha_i^2 \lambda_i^B)$$

$$- \lambda^S [(\mu(1 - P)(a\mu P - Y_1)(\Sigma_{i=1}^{n} \alpha_i^2 + 2 \Sigma_{i=1}^{n} \Sigma_{j=i+1}^{n} \rho_{ij} \alpha_i \alpha_j)$$

$$- (\lambda^S/2)((a\mu)^2 P(1 - P) + E(Y_1^2) - Y_1^2 - 2a\mu Y_1 (1 - P)) *$$

$$(2 \Sigma_{i=1}^{n} \Sigma_{j=i+1}^{n} \alpha_i \alpha_j (\partial\rho_{ij}/\partial a))]$$

In the text, of this chapter one case in which $(\partial\rho_{ij}/\partial a)$ might be greater than zero, moral hazard, was noted. For the purposes of this appendix, it is assumed that this partial derivative is zero. If the total derivative of this expression with respect to "a" and buyer i's risk aversion coefficient is taken, the resulting expression is:

$$(1) \quad d^2CE^S = [\Sigma_{i=1}^{n} \alpha_i^2 \lambda_i^B \mu^2\{f(a\mu)(Y_2 - Y_1 - a\mu(1 - 2P)) - 2P(1 - P)\}$$

$$- \lambda^S \mu^2\{P(1 - P) - f(a\mu)(a\mu P - Y_1)(\Sigma_{i=1}^{n} \alpha_i^2 + 2 \Sigma_{i=1}^{n} \Sigma_{j=i+1}^{n} \rho_{ij} \alpha_i \alpha_j)\}]da$$

$$+ [\Sigma_{i=1}^{n} \alpha_i^2 \mu\{Y_2 P - 2a\mu P(1 - P) + (1 - P)Y_1\}]d\lambda_i^B$$

Or, in a shorthand notation:

$$d^2CE^S = 0 = [*]da + [**]d\lambda_i^B$$

Which means

$$(da/d\lambda_i^B) = -[**]/[*]$$

Since the term [*] must be negative to be at a maximum, the sign of this ratio will depend upon the sign of the numerator. From the FOC we know [**] must be positive since the term multiplied by λ^S in the FOC is positive. This being the case, [**] must be greater than zero in order to satisfy the FOC. This means the $(da/d\lambda_i^B)$ will be positive and an increase in buyer i's risk aversion means the seller will offer a higher coverage level.

In the derivatives to follow we will continue to use the symbol [*] to represent the derivative of the first order condition with respect to the coverage ratio.

The derivative of the FOC with respect to a and α_i is:

$$(2) \qquad d^2CE^S = [*]da + [2\mu[\sum_{i=1}^{n} \alpha_i \lambda_i^B (Y_2P - 2a\mu P(1 - P) + (1 - P)Y_1)$$

$$- \lambda^S ((1 - P)(a\mu P - Y_1)(\sum_{i=1}^{n} \alpha_i + \sum_{j=i+1}^{n} \rho_{ij} \alpha_j))]]d\alpha_i \qquad \text{for } j \neq i$$

Again, in the shorthand notation,

$$d^2CE^S = [*]da + [**]d\alpha_i$$

or,

$$(da/d\alpha_i) = -[**]/[*]$$

The sign of this derivative is ambiguous since both terms that make up [**] are positive and one is subtracted from the other. The sign of the term, therefore, depends upon the relative magnitude of these two factors.

The derivative with respect to the optimal coverage ratio and the mean outcome of the uninsured distribution is:

$$(3) \quad d^2 CE^S = [*]da + [\sum_{i=1}^{n} \alpha_i^2 \lambda_i^B \{a\mu f(a\mu)(Y_2 - Y_1 + a\mu(2P - 1)) +$$

$$Y_2 P + Y_1 (1 - P) - 4a\mu P(1 - P)\} - \lambda^S \{(a\mu P - Y_1)*$$

$$(1 - P - a\mu f(a\mu) + a\mu P(1 - P))(\sum_{i=1}^{n} \alpha_i^2$$

$$+ 2 \sum_{i=1}^{n} \sum_{j=i+1}^{n} \rho_{ij} \alpha_i \alpha_j)\}]d\mu$$

or

$$d^2 CE^S = 0 = [*]da + [**]d\mu$$

and

$$(da/d\mu) = -[**]/[*]$$

Again, this is ambiguous because the sign of the term [**] is unknown.

The derivative of the FOC with respect to the coverage ratio and the seller's aversion to risk is:

$$(4) \quad d^2 CE^S = 0 = [*]da + [-\{\mu(1 - P)(a\mu P - Y_1)(\sum_{i=1}^{n} \alpha_i^2 +$$

$$2 \sum_{i=1}^{n} \sum_{j=i+1}^{n} \rho_{ij} \alpha_i \alpha_j)\}]\lambda^S$$

or

$$d^2 CE^S = 0 = [*]da - [**]d\lambda^S$$

and since the term [**] is positive, the expression

$$(da/d\lambda^S) = [**]/[*] < 0$$

This simply says that as the seller becomes more risk averse he will try to limit his exposure to risk by reducing the proportion of his clients' PDF that he is insuring.

The derivative of the FOC with respect to the coverage ratio and the correlation coefficient will be:

$$(5) \qquad d^2CE^S = [*]da - [-2\lambda^S_1(\mu(1 - P)(a\mu P - Y_1)(\sum_{i=1}^{n}\sum_{j=i+1}^{n} \alpha_i\alpha_j))]d\rho_{ij}$$

so
$$d^2CE^S = 0 = [*]da - [**]d\rho_{ij}$$

and
$$(da/d\rho_{ij}) = [**]/[*] < 0$$

This result also has intuitive appeal. If the outcomes of the insurance pool become more highly correlated, the insurer will reduce his exposure to risk by reducing the coverage ratio offered. An increase in the correlation coefficient increases the variance of the seller's returns without changing his expected returns. For this reason, it is understandable that the insurer would chose to reduce the coverage offered as ρ_{ij} increases.

And last, but certainly not least, the derivative of the FOC with respect to coverage and the average outcome over the uninsured portion of the distribution will be derived. This is by far the most complicated of the total derivative expressions. It may be expressed as:

$$(6) \quad d^2CE^S = [*]da + [(\partial\mu/\partial Y_2)((Y_2P - 4a\mu P(1 - P) + Y_1(1 - P))(\sum_{i=1}^{n} \alpha_i^2\lambda_i)$$

$$- \lambda^S(\sum_{i=1}^{n} \alpha_i^2 + 2\sum_{i=1}^{n}\sum_{j=i+1}^{n} \rho_{ij}\alpha_i\alpha_j) * (2a\mu P(1 - P) - Y_1(1 - P))) +$$

$$+ (\partial P/\partial Y_2)(\mu(Y_2 - Y_1 - 2a\mu(1 - 2P))(\sum_{i=1}^{n} \alpha_i^2\lambda_i^B) - (a\mu^2(1 - 2P) - \mu Y_1) *$$

$$\lambda^S(\sum_{i=1}^{n} \alpha_i^2 + 2\sum_{i=1}^{n}\sum_{j=i+1}^{n} \rho_{ij}\alpha_i\alpha_j))$$

$$+ (\partial Y_1/\partial Y_2)(\mu(1 - P)(\sum_{i=1}^{n} \alpha_i^2\lambda_i^B + \lambda^S(\sum_{i=1}^{n} \alpha_i^2 + 2\sum_{i=1}^{n}\sum_{j=i+1}^{n} \rho_{ij}\alpha_i\alpha_j))$$

$$+ \mu P\sum_{i=1}^{n} \alpha_i^2\lambda_i^B]dY_2$$

In general, this derivative cannot be signed.

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