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RISK AND UNCERTAINTY

How do farmers react to risk and uncertainty? What public policies have been adopted to meet the risks and uncertainties of agriculture in the Great Plains of this country and of Canada? These are the questions examined in this section.

Chairman Roy Huffman expressed his personal satisfaction that all four participants were present. "If any one of them had been unable to be here, I would have been in the same position as the circus manager when the human cannonball quit. 'Where can I get another man of his calibre'?"

Baker reviews the alternative responses of farmers to risk and uncertainty and discusses some policy implications. Thair reviews development of the Canadian Wheat Board and Stucky, the policies of the United States affecting risk and uncertainty on the Great Plains. Castle discusses each paper in turn, and concludes with some general observations on the subject. And from the floor a strong questioning: Is uncertainty all bad?

Farmer Response to Risk and Uncertainty

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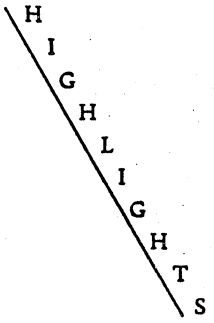

The alternative responses available to the farmer are:

(1) to reduce the incidence of unfavorable events by (a) diversification (in the Billings irrigated area, income variance due to price fluctuations could be minimized by growing potatoes, but at a sacrifice of income level attainable with dry beans); or by (b) increase in size of farm if by such an increase he increases the number of independently occurring events (this possibility is not likely to be of great significance) and

(2) to alter the economic consequences of unfavorable events by flexibility (a) flexibility in resource prices (the price of the farmer's own labor is forced to be flexible), (b) flexibility in organizational planning, and (c) flexibility in inventory management.

It is possible that areas of great variation in income may have a higher long-time average income. Uncertainty may be a restraining influence on size of farm, and an encouragement to tenancy.

Only part of the farmer's responses to uncertainty are economic. Other responses which may be of at least equal significance are psychological, sociological, political, etc. However, even such responses as these often require choice among alternative goals. This is basically an economic process. Other responses may entail reorganization of resources within the firm. Hence the economist is concerned with farmer response to uncertainty.

In fact, it may be said that the economist's concern with problems in uncertainty has been at least as active as has been permitted by his ability to classify and investigate these problems. The existence of uncertainty can hardly be overlooked. The only question is one of terms in which to conceive the problems and (in part, consequently) terms in which to search for data to use in their solution.

Risk and Uncertainty

Risk, Uncertainty, and Insurance

There is a tendency to date the economist's formal concern with "uncertainty" with Knight's Risk Uncertainty and Profit, first published in 1921.[1/] However, as early as 1901, Allan H. Willett found it possible, in his doctoral thesis at Columbia, to review a substantial amount of literature then already available which bore more or less directly on problems which appear familiar even in today's terms.[2/]

An expectation relative to a future event will be described by the term "risk" if it is a central tendency of a probability distribution of values (e.g., a mean) whose dispersion parameters (e.g., variance), can be estimated in terms of measurable probability of error. If they cannot be so estimated, the expectation will be described by the term "uncertainty." Whether or not such an estimate is actually made is irrelevant to the distinction. The critical point is that it can be made.

For some events, estimates are made. Then, if the error limits are not so wide as to preclude their usefulness, an actuarial basis is provided for insuring against at least some of the consequences of an unfavorable deviation from the expected value. Such events as fire, wind, hail, etc. furnish examples of distributions successfully used as a basis for insurance.

The size of the error estimate for a given event is a function of the number of independent observations. For events to be commercially insured, a satisfactorily large number of events must be insured before the insuring agent can assume the "risk" (to it) more successfully than the insured can bear the consequences of "uncertainty" (to him). For the incidence of fire, this "break-even" point evidently is reached fairly easily. For such weather phenomena as hail, it apparently varies widely by area. For other phenomena such as drouth, we apparently have yet to find the break-even point.

1/ Frank H. Knight, Risk Uncertainty and Profit, Houghton Mifflin Co., N. Y., 1921.

2/ Allan H. Willett, The Economic Theory of Risk and Insurance, U. of Pa. Press, Philadelphia, 1951 (reprint).

An important area of research involves determination of optima relative to the permitted deviation of events on the unfavorable side of the mean (or other central tendency). The wider the permitted deviation before indemnity the lower can be the cost of insurance, but also the less attractive are the returns from the policy. For events not yet commercially insured we need to continue experimenting in order to determine, for particular areas, the number of contracts required, given variation estimates. Or, conversely, perhaps the permissible departure from homogeneity in terms of the phenomenon in question could be sought in order to determine what size of area is required for particular events.

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For some phenomena, such as price, insurance is barely recognized as a potential alternative. though some income-proposals in the policy area have made certain insurance features. In case of uncertainty due to technological change and to inter-personal relationships, answers are not even sought in these terms. Risk and Uncertainty

Incidence and Consequence

We note that the insuring agent works with events whose deviations from mean expectations have important economic consequences. This is necessary for sale of policy contracts. However, the features which distinguish risks from uncertainties relate to the incidence of unfavorable deviation. Consequences are important only in selecting the event against which to insure and in selecting the tolerance limit, on the unfavorable side of the central tendency, beyond which to insure. The agent then proceeds to refine its predicting power and to increase its efficiency in countering the economic consequences, for itself, of the residual uncertainty which even it has been unable to remove.

There are two methods by which the farmer can simulate for himself some of the functions of an insuring agent which relate to incidence. One is through size, if by an increase in size he is able to increase the number of independently occurring events. The second is through time, if the temporal distribution has proper characteristics. Management limitations ordinarily restrict the effectiveness of size in agriculture in developing an actuarial base for "self-insurance." However, the spatial characteristics of dryland farming and stock ranching offer some possibilities in this direction. The limited life span of the individual farmer distinctly limits the temporal basis for actuarial calculations.

Even so, however, we suggest that for events which are significant in an income sense, yet uncertain in an actuarial sense, the farmer can profitably distinguish between incidence and consequence in developing useful techniques for countering the economic consequences of uncertainty. In fact, such a distinction immediately classifies his "responses" or the array of alternatives into two groups: (1) those which reduce the incidence of unfavorable events and (2) those which alter the economic consequences, given their incidence, in a manner favorable with respect to his goals.

Response Alternatives

To reduce the incidence of unfavorable events

Enterprise diversification has long been suggested as a method by which the farmer might reduce the unfavorable incidence of income uncertainty. Diversification is often more effective in raising the level of income than in reducing its variance. But there are important cases where diversification does reduce income variance.

Risk and Uncertainty

With a given quantity of resources allocable between two enterprises, E_1 and E_2, there is a decision whether to put (1) all the resources in E_1, (2) all in E_2 or (3) part in each. The decision will affect the level of income. It will also affect the variation in income. We will restrict our attention solely to the latter effect.

Let the variation in income of each, net of the expense of these allocable resources, be measured by its respective variance, σ_1^2 and σ_2^2. Then the total of such income varies by σ_T^2:

(1) $\sigma_T^2 = \sigma_1^2 + \sigma_2^2 \pm 2 r_{12} \sigma_1 \sigma_2$, where r_{12} is the simple correlation coefficient of the two income variables and gives the algebraic sign to the third term.

If all such resources are allocated to E_1, (1a) $\sigma_{Ta}^2 = \sigma_1^2$ if all to E_2, (1b) $\sigma_{Tb}^2 = \sigma_2^2$; if half to E_1 and half to E_2,

(1c) $\sigma_{Tc}^2 = (1/2)^2 \sigma_1^2 + (1/2)^2 \sigma_2^2 \pm 2 r_{12} (1/2 \sigma_1)(1/2 \sigma_2)$

$= .25 \sigma_1^2 + .25 \sigma_2^2 \pm 1/2 r_{12} \sigma_1 \sigma_2$. 1/

In the Billings area on irrigated farms, dry beans are considered, on the average, to be a highly profitable crop. Budget estimates of the income effect of dry beans bear out this belief. 2/ However, they are also considered to be highly uncertain, due mainly to price uncertainty. During the period 1920-52, dry-bean prices in Montana varied from $1.41 to $7.56 per cwt. 3/ The coefficient of price variation is estimated at 86 per cent. It seems likely that this would also be a minimum estimate of variation in net farm income. Hence a farmer producing dry beans might reasonably be expected to seek some means of reducing his income variation due to price. Yet he might want to continue producing dry beans for their effect on income level.

1/ For derivation and further application of these relationships, see E. O. Heady, Economics of Agricultural Production and Resource Use, Prentice-Hall, Inc., N.Y., 1952, pp. 514-522.

2/ See J. P. Doll, Economic Application of Soil Survey Data, Mont. Ag. Exp. Sta. Mimeo. Cir. 87, June, 1955, p. 88.

3/ M. C. Taylor, P. J. Creer, et al, Prices Received by Montana Farmers and Ranchers 1910-1952, Mont. Ag. Exp. Sta. Bul. 503, Nov., 1954, p. 39.

Suppose he turns to potatoes, also variable in price, though not nearly so much so as dry beans. They varied, 1920-52, between the extremes of $0.50 and $3.17 per bushel[1/], with a coefficient of price variation of 27 per cent. Moreover, though the prices of dry beans and potatoes are positively correlated, the coefficient of price correlation is only about 0.31.

Diverting half the allocable resources from dry beans to potatoes, we estimate, with equation (1c),

$$\sigma_{T_C}^2 = .25\ \sigma_1^2 + .25\ \sigma_2^2 + \tfrac{1}{2}(.31)\ \sigma_1\ \sigma_2$$

From this relationship, we derive the maximum price variance in potatoes which will permit such a reallocation of resources without increasing $\sigma_{T_C}^2$. This requires (2) $\sigma_{T_C}^2 \leq \sigma_1^2$ or, substituting,

$$.25\sigma_1^2 + .25\ \sigma_2^2 + \frac{.31}{2}\sigma_1\ \sigma_2 \leq \sigma_1^2.$$

Solving for the maximum permissible σ_2^2, we have (3)

$$\sigma_2^2 \leq 3\ \sigma_1^2 - 0.62\ \sigma_1\ \sigma_2.$$

Available evidence gives estimates of price variance for dry beans and potatoes, respectively, at $4.40 and $0.34. Hence,

(4) $$0.34 < 3(4.40) - 0.62\,(2.10)\,(0.58) < 12.44$$

indicates that such a resource diversion would reduce income variation.

Given the variance in income with respect to price in each of the enterprises, it is also possible to derive the maximum price correlation which will permit a diversion of half the allocable resources from dry beans to potatoes without increasing total variance. Any correlation less than that given in the following expression will make the combined variance smaller than the variance for dry beans alone:

(5) $$r_{12} = \frac{.75\ \sigma_1^2 - .25\ \sigma_2^2}{\sigma_1\ \sigma_2}$$

Turning again to the Billings area, the coefficient of price correlation between dry beans and potatoes could, in fact, be as much as 1.0.

An addition to size of farm with no change in enterprise organization will tend to improve the estimates (i.e., to reduce the standard errors of estimates) of any events which differ spatially. However, these events are seldom of much significance over the range in size customary in agriculture. On the other hand, when a new enterprise is added without diverting resources from an existing enterprise, it is seldom possible to reduce income variance. It may sometimes pay, in terms of income level, to diversify with an increase in farm size. But it is likely to be a fairly rare instance where a second enterprise can reduce the variation in income for the increased farm size, relative to the original. From equation (1), we see that $r_{12}\ \sigma_1\ \sigma_2$ must be less than 0.0 and by a large enough amount to offset the necessarily positive σ_2^2

The foregoing example deals with variance in income net of allocable resources due to product price variation. For enterprise combinations in which allocable resources are not particularly significant, the

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1/ Ibid., p. 38.

results will also not be particularly significant. One simple means by which to make the method more generally applicable is to make price for each product net of the expense of resources which are specific to each enterprise. However, this technique is cumbersome except for cases where these expenses are linear functions of output in each enterprise.

To alter consequences of unfavorable events

After available measures have been used, to their optima, in reducing the incidence of those unfavorable events which are non-insurable, the farmer is next interested in reducing the severity of their economic impact. This problem carries us into a new array of alternatives, related mainly to organizational flexibility. By "flexibility" we mean the ability of the farmer to change plans on revision of expectations.

The pioneering theoretical work of Hart[7/], Stigler[8/], and others has yet to produce the emperical product it deserves. Yet flexibility almost certainly represents an important farmer response to uncertainty. Farmers are often observed to make choices which give comparatively inefficient producing systems if they obtain thereby a wider array of alternatives in the event of unforeseen developments (e.g., a change in price, weather or technique).

Flexibility in resource prices

In any given time span, the total cost of operating a farm can be divided into two parts: (1) the cost of resources owned by the farmer and his family, and (2) the cost of resources furnished from outside the farm business. The latter group of resources gives rise to what we term "farm expense"; the former group, to "imputed" costs, where the rate of imputation depends on alternatives available for the use of the farmer-owned resources. In a sense the imputed costs are "paper" costs only. They represent cost commitments only in the degree to which the alternatives are real and significant.

Of the various resources which are bought by the farmer and which thus give rise to "expense," there are, occasionally, opportunities to choose between resources which are flexibly priced and those which are not. Examples are found in livestock production where the selection of a ration often favors an ingredient which comes directly from its agricultural source rather than indirectly through a mixed feed. The mixed feed may give results which, on the average, justify its use in terms of income level. Yet, if it is inflexibly priced, it may run into feeder resistance.

Perhaps the impact of stilbestrol, which necessitates the use of prepared feed mixes and at daily rates which exceed what many farmers would otherwise feed, needs to be investigated in terms of its effect on the consequences of price uncertainty in livestock. Another problem which has received some attention, relates to the effect of publicly supported prices for crops whose products become inputs to the livestock

1/ A. G. Hart, Anticipations, Uncertainty and Dynamic Planning, U. of Chicago Press, 1948, esp. Ch. IV.

2/ G. Stigler, "Production and Distribution in the Short-Run," JPE, V.47.

farmer. Under certain conditions relating to supply-and-demand elasticities, the livestock man might eventually benefit from crop price supports, in terms of income level. Meanwhile, the consequences of uncertainty in livestock prices tend to be made more severe.

It is well known that on commercial family-operated farms, the labor of the farmer and his family comprises a large (fixed) component of the total cost. Yet these same farms show remarkable "staying power." And, probably due to this characteristic, they compete successfully, in most instances, for the use of agricultural resources. The "staying power" is attributable, of course, to the (forced) flexibility in the price of farmer-owned labor.

One of the more important economic problems which now confronts such farm families is the increasing cash commitments for family living. This trend reduces the effective flexibility in price for farmer-owned resources. In turn, this reduction affects competitive position of the commercial family-operated farm.

Flexibility in organizational planning

Suppose a farmer must make a decision at point t_0 in time, which commits resources through points t_1 and t_2. Much research is done and many recommendations are made on the assumption that the farmer chooses an optimum plan on the basis of means of expected values at t_1 and t_2. Yet it has been shown that the sum of expected net receipts, discounted to t_0, may depend on dispersions as well as means. 1/

Still more significant is the possibility that the mean estimate for t_2 made at t_0 will differ, in general, from the mean estimate for t_2 made at t_1. As time passes and more information becomes available, errors in original estimates are uncovered while the error variance in forward mean expectations are reduced. Both of these occurrences encourage the farmer to select a plan at t_0 which is relatively flexible--i.e., one which will permit greater freedom for him to revise his organization at t_1, when more information has been made available.

Choice among plans which differ in degrees of flexibility is affected in part by the learning process of the farmer involved. The farmer who learns readily and who is willing to commit resources to this purpose will anticipate a greater increment in knowledge between t_0 and t_1 than will the farmer less apt or less motivated to learn. Hence the former will tend to choose the flexible plan while the latter will more likely try to solve his problem "for once and all" on the basis of his knowledge at t_0.

This interesting area, pioneered in agricultural economics by Johnson and Haver, is likely to receive considerably more attention in

1/ A. G. Hart, "Risk and Uncertainty, and the Unprofitability of Compounding Probabilities," Studies in Mathematical Economics and Econometrics, U. of Chicago Press, 1942.

the future.[1] The recent fundamental methodological work of Bush and Mosteller in psychology is likely to further the interests of both psychologists and economists in this area.[2]

Flexibility in inventory management

The writer is acquainted with a successful dryland operator in north central Montana who attributes much of his success to a very simple rule of thumb. In any given year, he owns four crops of wheat: one in the bank, one in the bin, one growing and one yet in the soil (in summer fallow). With this type of inventory management and by staying abreast of technological developments, he has demonstrated considerable ability to survive severe fluctuations in both yield and price, meanwhile accumulating farms of those less willing to undertake a systematic plan in inventory management.

Risk and Uncertainty

The crop "in the bank" and the one "in the bin" obviously combine to reduce the effects of price uncertainty which are yielded by either taken alone. The one "growing" and the one "yet in the soil" are combined to reduce the incidence of unfavorable yields while not sacrificing unduly in terms of production in good-weather years. Here, then, is a specific response which has "worked" in a single case. How widely applicable is this plan as (1) debt position varies? (2) as size of farm varies? (3) as weather conditions vary? etc.

It is clear enough that agricultural lenders employ crude rules of thumb, relative to the farmer's balance sheet, in order to avoid assumption of the farmer's uncertainty. These ordinarily develop over time from experience in specific areas and for specific types of operations. Might it not also be possible that the farmer would benefit from some "rules of thumb" to guide him in appraising the security of his financial position? Or in making a decision which would involve substantial changes in his asset and/or liability proportions?

Such rules of thumb would likely vary by size of farm. For example, consider two farms with net worth of $50,000 each. One has assets of $100,000 and debts of $50,000. The other has assets of $80,000 and debts of $30,000. Given a price reduction of 10 per cent, the net worth of the first farm goes to $40,000, a reduction of 20 per cent; the net worth of the second farm goes to $42,000, a reduction of 16 per cent. The larger the size of farm, for a given net worth, the greater is its exposure to price uncertainty in its assets. This simple relationship underlies the "principle of increasing risk" with which Mr. Kalecki attempts to explain effective limitations to size of firm under conditions of pure competition.[3]

1/ Glenn L. Johnson and C. B. Haver, Decision-Making Principles in Farm Management, Ky. Ag. Exp. Sta. Bul. 593, Jan., 1953.

2/ Robert R. Bush and Frederick Mosteller, Stochastic Models for Learning, John Wiley & Sons, Inc., 1955.

3/ M. Kalecki, "The Principle of Increasing Risk," Essays in the Theory of Economic Fluctuations, Allen & Unwin, Ltd., 1939, pp. 95-106.

Policy Implications

Many public programs attempt to deal directly with problems in uncertainty; crop insurance, emergency credit, and others. Such programs as these ordinarily are designed to reduce the severity of the consequences of unfavorable events, though an important part of the crop insurance program is aimed toward research in measurement of incidence as well. It may be noted, in passing, that as farmers begin to depend on such programs as these, the threat of change in programs introduces still a new source of uncertainty. For example, many acres were seeded to wheat, cotton, and corn a few years back in anticipation of acreage allotments. The price of fixed assets in hazardous farming areas are almost certain to reflect any assurance of regulated relief through either direct payments, subsidized crop insurance, or emergency credit based on non-commercial criteria.

It may be a reasonable hypothesis that, as among areas which differ with respect to income variation (from price or yield variation), the average net farm income, over a long term of years, will tend to be higher, ceteris paribus, in the areas with the larger variation. If this were shown to be true, it might suggest that programs designed to counter the effects of uncertainty may not be unmixed blessings for farmers so "favored." The fact that farmers seem to be largely unaware of this possibility simply attests to the need for research in the area and, if the hypothesis is supported, educational activity in this sensitive policy area as well as in developing successful plans for meeting the effects of uncertainty on an individual basis.

Finally, uncertainty also has an important effect on tenure problems in agriculture and, in particular, on problems of securing entry into farming. If Mr. Kalecki's hypothesis is empirically significant, uncertainty is an important factor in restraining increase in farm size. It may also explain why, in areas of high uncertainty, there is a tendency toward more tenant operation, many under crop share leases. This is one means of inducing specialization in the function of uncertainty-bearing. The frequency of part-owner operations also suggests that there may be a tendency to search for some sort of optimum in this type of uncertainty-bearing.

Some programs, through techniques of group action, succeed in measurably reducing the area of uncertainty. Consequent improvement in resource efficiencies leave little doubt that such programs as these are economically beneficial--certainly to society, and probably to farmers as well. It may be questioned, however, whether public programs which propose merely to shift the consequences of uncertainty from farmers to society are really beneficial to farmers over the long pull. Here, then, is still another area for important research which is fundamental to the welfare of both farmers and society as a whole.

Discussion

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My reaction to Baker's paper is that he gives us a competent, tightly reasoned review of the general measures farmers may undertake as a response to their uncertain environment. It is internally consistent, the classification used is neat, and the illustrations and suggested applications are interesting. I rather wish, however, that Baker had spent less time on the theory which has been developed for some time and had concentrated more on the implications of risk and uncertainty regarding the way farms are managed. It seems to me such an analysis could have taken one of two directions. One path might have been to examine the effect of the psychological, sociological, political, and economic responses, which Baker mentions, on the use of agricultural resources. This leads us into a theory of management and it is this road that Glenn Johnson has followed. This is a logical development since the presence of risk and uncertainty is certainly a major if not the reason for management. How will subjective values affect the way in which resources are managed? How will variations in ends or value systems of farmers affect the amount of diversification they will desire and the kind and type of flexibility they will incorporate into their farm organization? Glenn Johnson has been a leader in this work and has made available some theoretical as well as some applied stock. Other agricultural economists have done work in this field and in some respects I think we have gone beyond the general economists. Let me quote from a recent work of Johnson's; "Our study indicates that research should be done on ways and means of increasing the skill with which the five managerial tasks (observing, analyzing, decision making, acting, and bearing responsibility) are performed. The study also indicates that much research is needed on the roles which subjective values play in the management of farms, that is, the subjective importance of income changes, of security, of flexibility, of the results of learning and such. Apparently farm management research needs to be reoriented toward solving managerial problems of farmers rather than toward the problems of organizing and operating farms."[1/] Should we give some attention to such a conclusion? It seems to me Baker's paper would point our research in another direction. I may be wrong in my interpretation but what I am saying is that I would have preferred Baker's theories on such questions to his restatement of the theories of others.

Risk and Uncertainty

From Baker's research suggestions I conclude that he would more nearly take the direction Heady and some of his students have taken in their research. Their procedure has been to start from the principles Baker stated here today and collect data relating to diversification, flexibility, and liquidity. This research is oriented toward problems of organizing and operating farms. We have accumulated a goodly number of such studies and they are continuing to be made. I would have found an appraisal of this work extremely useful. Are these studies of value? If not, why not? It seems to me the time has come in this field to push beyond Knight and Hart. We have the choice of reformulating the theory

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1/ Glenn L. Johnson, Managerial Concepts for Agriculturalists, Bul. 619, Ky. Ag. Exp. Sta., July, 1954.

in the hope of making it more suitable. This is the course Johnson has chosen. The other road leads to empirical work guided by the present theory. In the latter case our emphasis now, it seems to me, should be on empirical results, methods, and procedures. I personally would like to see work continued on both fronts although a division of labor may be profitable.

My other comments on Baker's paper are minor in nature. The statistical problems involved in the use of the diversification model Baker presented are a bit complex. If the model is used to combine unlike distributions, such as wheat and milo, the combined variance cannot be tested for significance. We must therefore fall back on more subjective interpretation of the results than otherwise. Using this model it was found in Western Kansas that spatial diversification is about as effective in reducing variation as product diversification.[1/] This is a hypothesis that Baker mentioned that has been tested in one location. It needs to be tested in others.

Risk and Uncertainty

Baker's discussion of flexibility seems to me a creditable one. I am all for providing rules of thumb to farmers relating to their financial security. It is interesting to note that in some case studies Glenn Johnson made in Kentucky the "principle of increasing risk" had little effect on farmers' decisions. In another area or for a larger sample this may not hold. Despite the fact that bankers have "rules of thumb" to help them in making such decisions, I believe they need help about as much as farmers in this respect. I wonder if their "rules of thumb" have not become a bit inflexible. Thair was also a bit skeptical of the "rules of thumb" of lending agencies.

One final point regarding Baker's "Policy Implications" should be made. He states that if, over the long run, net farm income in the high risk areas is higher than in other areas and if public programs are instituted to counter the high risk in these areas that income may suffer. With this I agree. He goes on to say that farmers seem to be unaware of this possibility. Here, I would raise a question. Is it not possible that some farmers are aware of this possibility but are willing to sacrifice some income to obtain greater certainty? I am no expert on farmer attitudes but people in all walks of life take these same precautions. There appears to me no reason to expect that some farmers might not do likewise. I would classify such action in Baker's framework as avoiding the incidence of the unfavorable event.

1/ Castle, E. N., Journal of Farm Economics, Vol. XXXVI, May, 1954, p. 273.