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RISK AND UNCERTAINTY: THE ROLE OF INFORMATION

David L. Debertin and
Garnett L. Bradford

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Risk and Uncertainty:
The Role of Information*

D.L. Debertin and
G.L. Bradford

I

Let us first introduce a model of the impact of information on an entrepreneur's adjustment to situations in which risk and uncertainty is involved. For the moment, the terms "risk" and "uncertainty" will be used interchangeably to denote situations in which outcomes of interest to an entrepreneur are influenced by random (stochastic) events.

Contention 1. *The concept of "information" as a phenomenon of concern to entrepreneurs is inextricably linked to the concept of risk and uncertainty.* At one end of the continuum an entrepreneur is faced with zero risk and/or uncertainty. This implies perfect or total information. At the opposite end of the continuum, an entrepreneur deals with a condition under which uncertainty is total. This implies a total lack of information.

The aforementioned conditions of zero and complete information are polar positions for the entrepreneur. In the real world, the entrepreneur is normally operating within an environment in which partial but not complete information is available. Figure 1 illustrates an information-

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risk hierarchy representing the alternative levels of information available to an entrepreneur. Associated with each level of information within the heirarchy is a corresponding risk and uncertainty level.

The model outlined in Figure 1 transcends the traditional dichotimous definitions for risk and uncertainty. Since Knight's book appeared in 1921, (see also Doll et al., pp. 182-209), it has been customary to use the term uncertainty to denote a situation in which the outcome or outcomes arising from decisions made by the entrepreneur are stochastic and the probabilities associated with each outcome are unknown, whereas, risk has been used to denote a similar condition in which probabilities are known. It is more useful to speak in terms of a risk-uncertainty continuum as illustrated in Figure 1. The model illustrates quite clearly the close association between the amount of risk and uncertainty and the level of information available to the entrepreneur.

A key problem faced by those conducting research ultimately to be used by decision makers involves a recognition of a twofold task:

(1) the delineation of the outcome set with accompanying estimates of probabilities, and

(2) the identification of the information level existing when the problem is formulated.

A general mathematical formulation of the model is shown by the function

$$U = f(I, X) \qquad (1)$$

Where:

U = the risk or uncertainty condition,

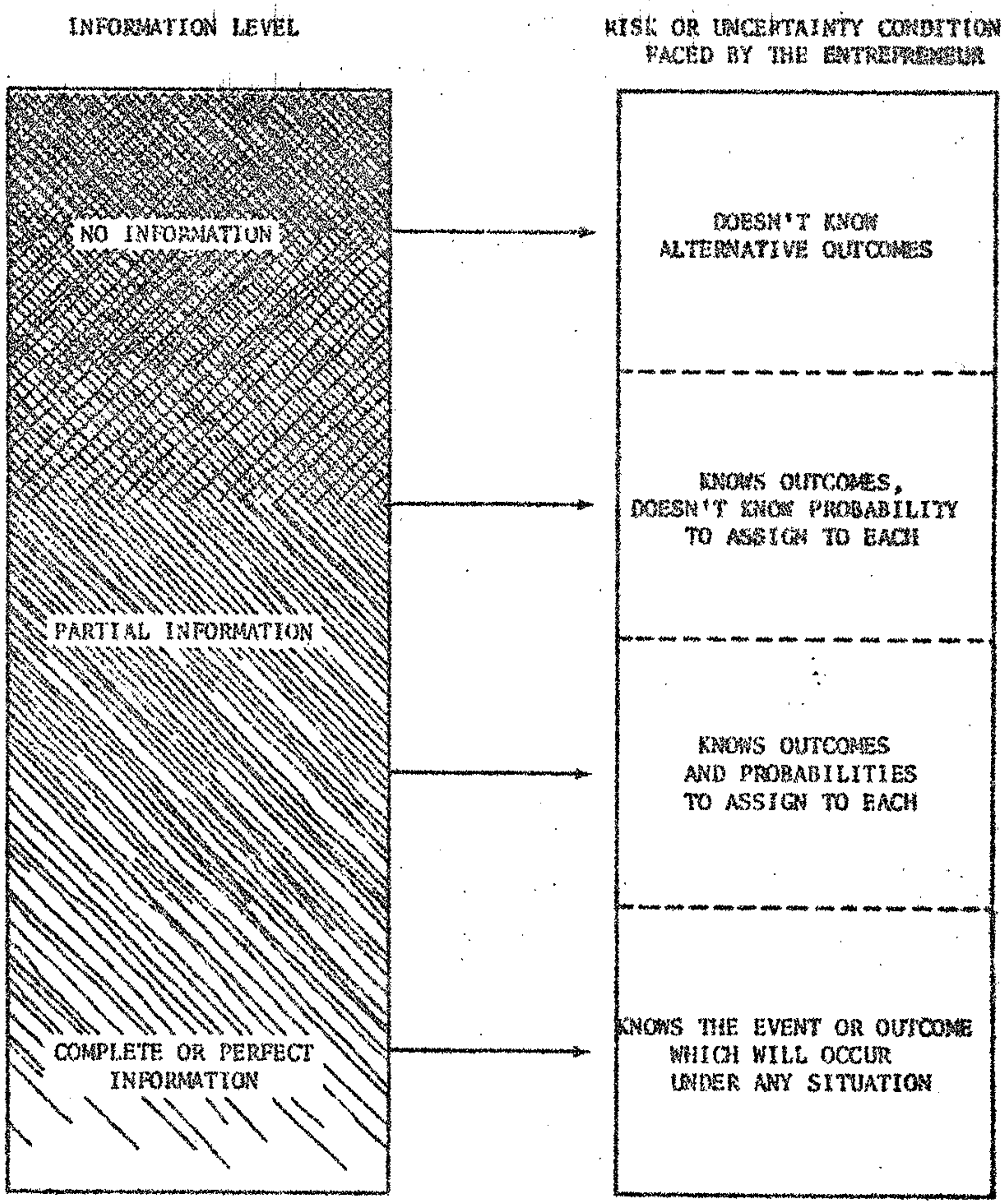

Figure 1. An Information-Risk Hierarchy

I = level of information ordinarily available to the entrepreneur,

and

X = information which is either exogenous to the firm or is misinformation

We can postulate that

$$I = g(R, F) \qquad (2)$$

Where

R = research information which the entrepreneur could acquire from sources external to the firm, e.g., input suppliers, land grant universities, other public or private research centers, newspapers, media, closely related firms (see Eisgruber).

F = feedback information from past experiences of the firm's managers. This feedback information frequently is only partially documented in the firm's records; much of it may be a rather complicated memory set, unique for each firm's entrepreneur. For example, a detailed set of farm records might be excellent feedback information.

Exogenous information is a function of political, social, economic and environmental variables.

$$X = h(S, E) \qquad (3)$$

Where

S = combined political, social and economic forces (a policy variable)

E = environmental forces including the weather and the availability purchased inputs

Relations (2) and (3), for the most part, are not simultaneously determined. The value of X cannot be independent of I. That is, efforts by the firm to acquire information [R and/or F] are related to the level of X. Usually we think this relationship is direct, i.e., information acquisition efforts or the cost of obtaining information must be intensified as X becomes greater.

A dynamic version of Figure 1 could show a series of outcome-probability hierarchies alternated singularly with a series of information-level sets. One might liken it to the frames of a movie film. The first two frames are depicted in Figure 1. Subsequent frames possess the same general appearance, but are altered by the passing of time.

The dynamic mathematical model follows from differential calculus of expressions (1) - (3) as

$$dU = \frac{\partial U}{\partial I} dI + \frac{\partial U}{\partial X} dX \tag{4}$$

$$dI = \frac{\partial I}{\partial R} dR + \frac{\partial I}{\partial F} dF \tag{5}$$

$$dX = \frac{\partial X}{\partial S} dS + \frac{\partial X}{\partial E} dE \tag{6}$$

To complete this dynamic theory one should know whether explanatory variables in each expression, (1) - (3), are interrelated or independent, and the postulated algebraic sign (+ or -) of each partial derivative in (4) - (6). Consider expression (4). We hope to specify I and X to be independent, and normally we visualize that U can be reduced by increasing I and/or decreasing X. That is, dU is positive when the expected positive effect of $\frac{\partial U}{\partial I} dI$ more than offsets the expected negative effect of $\frac{\partial U}{\partial X} dX$.

Contention 2. *The presence of stochastic processes leads entrepreneurs to often make the wrong move when dealing with decisions in which outcomes are decidedly non-stochastic.* The isolation of causal relationships is often quite difficult for an entrepreneur facing stochastic processes.

An illustration is the situation faced by the Great Plains dry-land wheat farmer who must face a decision regarding levels of nitrogen fertilizer on wheat. Agronomy farm test plot data has been available for decades on the response of wheat to varying nitrogen levels. As a production economist might anticipate, the responsiveness of wheat to nitrogen does indeed depend on the level of rainfall during the growing season. However, within a realistic range of nitrogen fertilization levels, there has never been any consistent evidence to support the belief that in low rainfall years, that the presence of adequate levels of nitrogen reduces yields. Indeed, there is substantial evidence to support the idea that responsiveness of wheat to nitrogen is quite strong even in years of moderate drought. The agronomists have been telling this story in an extension context for years. Yet a high proportion of farmers resist the application of nitrogen fertilizer solely on the grounds that in a dry year yields will be reduced.

What has happened is that the presence of a highly stochastic event - rainfall in the dryland Great Plains wheat area - has influenced farmers decisions regarding a variable in which the outcome is relatively non-stochastic - the responsiveness of wheat to nitrogen fertilizer. The farmer faced with low wheat yields in a drought situation is unable to isolate the separate effect of the variable he can not control (weather) from the effects of the variable he can control (nitrogen fertility levels). The natural tendancy is to blame the outcome on a variable which the farmer can control and make a different decision regarding nitrogen fertilization levels the following year.

III

Contention 3. *The "invisible hand" which should act to guide farmers to the value of a decision variable which will maximize expected total profits over a long-term planning horizon is very weak, and perhaps nonexistent.* This is perhaps a corollary to Contention 2, and is a point that comes through quite clearly when analyzing the results of our studies dealing with the returns to information in a behavioral laboratory environment (Debertin et al., 1974, 1975a, 1975b, Rades et al., 1975, Debertin et al., 1976).

The first study utilized a computerized farm management game to estimate the returns to research and feedback information (Debertin et al., 1975a). Participants in the experiment were students in an advanced undergraduate farm management class. Participants in the experiment were assigned to 1 of 4 groups. The basic experimental design is shown in Figure 2.

	No Information	Information
No Feedback	Group 1	Group 2
Feedback	Group 3	Group 4

Figure 2. The Treatment Design

Managerial decisions within the game dealt with key aspects of corn and soybean production. Research information utilized within the laboratory environment was similar to that provided through research and extension bulletins. Feedback approximated a detailed set of farm records. Mean profit levels for the four groups of participants are presented in Table 1. An analysis of variances indicated significant returns to both the research information and feedback in this experiment.

Participants in this experiment faced with a situation of having rather complete information on the outcomes of decisions made in previous time periods via quasi-farm records data but lacking research-extension information dealing with values for decision variables which would tend to maximize profits over the long-term tended to approach managerial decisions very much on a trial and error basis. The presence of stochastic events seems to confuse the participant who was attempting to zero in on some optimal value for a decision variable. In fact, there was subtle evidence to support the idea that "correct" research and extension information provided by a land grant university may be more valuable to the farmer (in terms of increased profits) than excellent feedback information such as that provided by a detailed set of farm records.

Participants in the second laboratory experiment (Debertin et al., 1976) consisted of 39 experienced corn and soybean farmers from 6 central Indiana counties. This research focused entirely on the estimation of the returns to research information. Hence, farmers were divided into only two groups (with and without research information) instead of four. The identical management game was used in both experiments. Data in Table 2

Table 1. Mean Profits Generated Per Year for Each of Four Treatments, Five Years of Operation, Student Participants

Decision Period (year)	Treatment I No Information No Feedback	II Information No Feedback	III No Information Feedback	IV Information Feedback
1	-3,314	-1,316	-2,292	-504
2	11,978	16,554	14,084	19,316
3	13,814	19,553	17,787	25,267
4	343	5,021	4,099	7,177
5	20,475	24,235	25,990	28,073
Average of 5 years	8,659	12,810	11,935	15,866

Source: Debertin *et al.*, 1975a.

Table 2. A Comparison of Profits Generated with the Game for Students and Farmers

	Farm Management Students		Experienced Farmers[a]	
Year (Decision Period)	Without Research Information	With Research Information	Without Research Information	With Research Information
1	-2,292	-504	-2,746	-3,897
2	14,094	19,316	9,801	12,507
3	17,787	25,267	12,482	14,909
4	4,099	7,177	-152	1,583
5	25,990	28,073	23,977	23,519
Average of 5 Years	11,935	15,866	8,672	9,724

Source: Debertin *et al.*, 1976.

reports the results of the experiment for experienced farmers. Again, there is evidence of a positive return to research information for the experienced farmers. This conclusion was statistically supported by an analysis of variance. Note also that the experienced farmers did not do as well at running the computer game as did the student participants. There is also weak evidence that the return to information was not as great for experienced farmers as it was for the students.

All of this leads to the general conclusion that research and extension information as produced by land grant colleges may be extremely valuable, particularly for inexperienced farmers. We are not necessarily advancing the idea that farmers should blindly follow the advise of the extension service without paying any attention to the outcome occurring as a result of that advice. We are arguing that research and extension information supplied to farmers (such as data on fertilization) tends to have the stochastic (in the case of fertilizer weather) year-to-year variation averaged out, and may therefore be highly valuable to a farmer since this is the kind of information the farmer needs in order to find the expected value for the decision variable that maximizes expected profits. Another observation is that many farmers tend to stick doggedly with the set of decisions made in some historical high profit year regardless of the reasons for the high profits in that historical year. All of this makes the extension service's role very difficult in attempting to cause farmers to change the value of a decision variable in an effort to increase farmers profit levels.

IV

Extensive research efforts aimed at isolating values for decision variables which maximize expected profit levels over a long-term planning horizon have perhaps not been clearly identified as important efforts in helping farmers cope with a stochastic world. Indeed, any efforts designed to provide the farmer with information useful in the selection of the optimal value of a decision variable (the value of the decision variable that will maximize expected profits) will enable the farmer to better cope with stochastic processes within the real world. For example, a fertilization strategy which a farmer should pursue should be largely the same from year to year -- fertilization levels should be those which maximize long-term profits. (If the biological scientists were only aware that there is a difference between the value of a decision variable that maximizes profits verses the value of a decision variable that maximizes output!)

In addition to a knowledge of the value of a decision variable which maximizes expected profits over a long-term planning horizon most farmers would also find information with regard to the deviations around expected profit levels that might be anticipated over the planning horizon. The percentage variation in profit levels over a long-term planning horizon will be substantially greater than the percentage variation in either yields or prices. Most farmers are not capitalized to the point where they can pursue a decision strategy that maximizes expected profits over the long-term, but may entail several consecutive years of zero or negative profits.

Strategies involving the use of any form of insurance are normally not profit maximization strategies. Insurance is popular in instances where (1) the financial loss to the entrepreneur is great if the event being insured against occurs, and (2) the cost of the insurance is a relatively small proportion of the entrepreneurs income during any year. A relatively high cost crop insurance might be purchased by a farmer if (1) the farmer is unwilling to accept normal variation in profits due to yearly changes in yield levels, or (2) the farmer has reason to believe that the probabilities which the insurance company has attached to yields in his area are somehow different from the probabilities expected on his own farm. In general, an insurance strategy is a zero-sum game less the return to the insurance company (house).

Computer simulation models have proven to be especially valuable as a research tool for tracing out variations in prices, yields and profits that might be expected over a long-term planning period. Such models are useful not only from the standpoint of providing the researcher with data on normal variation over time, but for other reasons as well.

1. The researcher is forced into a situation where he must delineate what is stochastic and what is not. This is essential for the understanding of the behavioral, intitutional and technical relations modeled within the simulator.

2. However, the real value seems to lie not in the fact that one can model the real world with all its complexities and random events, for a model that is a perfect mirror of the real world is no model at all. Rather, the real value lies in the fact that the researcher has

"left out" some variables, and this "simplification" of the real world enables the researcher to focus on and isolate the causal relationships that are really important.

3. Computer simulations enable the researcher to work directly with *ceteris paribus* assumptions. There may be some value in seeing the output from the simulator (i.e., yield and profit levels) for each year of a 20 year planning horizon. However, the simulator may also prove quite useful in an analysis of the effects of a change in a single decision variable with all stochastic events held constant at predetermined levels.

V

Although research personnel at land grant universities have spent a great deal of effort aimed at isolating optimal values for decision variables, relatively little effort has been placed on improving methods of information delivery. The information delivery system faced by the farmer is exceedingly complex. Information varies not only in source, but in quality as well (Eisgruber, Lee).

The research or extension bulletin aimed at a very specific decision has been the mode of information delivery most popular at land grant universities, possibly because this is the kind of publication activity which tends to be rewarded by deans and administrators. However, farmers do not make each managerial decision in isolation from all others. Researchers and extension personnel when preparing materials for farmers need to think not only in terms of the reward system within land grant colleges but also in terms of how the information might actually be used by farmers.

Any system which makes information leading to an optimal decision more readily available to farmers will better enable farmers to cope with risk and uncertainty. A few states have adopted the practice of combining all materials on a broad subject matter area (such as "soybean production") in a single (perhaps looseleaf) binder. In the case of crop production, such material might encompass not only agronomic information, but information from economics, entomology, plant pathology and other disciplines. A major undertaking is that of setting up the administrative organization needed to develop such a comprehensive approach toward publication of research findings.

At Kentucky, as in many other states, work is progressing rapidly in the development of computerized information networks designed to place computer terminals in local county agents offices. Such information networks hold great promise as effective technology for dealing with decision-making in a stochastic world. Perhaps the greatest advantage lies in the fact that information can be put into a computer system much more rapidly than a research or extension bulletin be published. Hence, such systems are particularly useful for information dealing with decisions where timeliness is of the essence. Moreover, such systems will enable farmers to make use of highly complex decision models for the analysis of "what if" kinds of questions.

VI

Where does this leave us?

Some have argued that we have been overly preoccupied with models that assume perfect knowledge particularly with respect to prices and the form of the production function. Yet, with minor modifications, these models can often be used to handle situations in which the goal is to find the expected value of a decision variable that maximizes total profits over a long-term planning horizon when both prices and the form of the production function is stochastic. This is the essential first step in dealing with an environment characterized by risk and uncertainty.

We are beginning to know something about the value of information as a tool for dealing with risk and uncertainty faced by farmers. It seems to us that the greatest issue is not whether information is useful, but rather the fact that the information system faced by farmers is often highly disorganized. Information delivery is far more complex than it need be. Perhaps a farmer is faced with too many sources of information rather than not enough. The "quality" of information is also of major concern. We know almost nothing about the processes by which a farmer gleans what he feels to be high quality (correct) information from poor quality (incorrect) information. We suspect that many farmers are extremely inefficient in this regard. Empirical research efforts need to be directed toward: (1) an analysis of the comparative effectiveness of the various modes of information delivery including both traditional modes (such as the county agent - extension bulletin complex) as well as newer and more technologically sophisticated systems (the remote computer terminal; and (2) an analysis of processes by which farmers are able to separate what they feel to be "correct" information from "incorrect" information. A research project at the University of Kentucky has been designed to provide insight into both of these objectives. Through the use of computerized management games in a behavioral laboratory environment, it is hoped that initial comparisons of the effectiveness of alternative modes of information delivery might be made. Such experiments might be constructed utilizing a design similar to our earlier studies. Treatments may consist of alternative information delivery systems. Treatments might also include both "correct" and "incorrect" information.

Much remains to be done. It is clear that the problem of assisting farmers in dealing with situations characterized by risk and uncertainty reduces to a problem making high quality (correct) information available to farmers. Potential researchable problems are nearly limitless. The behavioral laboratory environment utilized in conjunction with computerized management games holds much promise as a tool for researching some of the problems outlined in this paper.

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