ABSTRACT

UTILITY, PROBABILITY, AND THE ADOPTION OF AGRICULTURAL INNOVATIONS

By

S. KENNETH SHWEDEL

The decision to adopt an innovation is seen as dependent upon the farmer's perception of: 1) the possible return from the innovation; and 2) the probability that that possibility will, indeed, be realized. The institution's role is to provide information concerning the innovation and facilitate the acquisition of any additional and/or new inputs which would be required to utilize the innovation.

If the institution is perceived by the farmer as being unreliable, he will discount (doubt) the information and the promise of additional inputs to be made by the institution. This, in turn, would lower the expected value to be received from adopting the innovation. It is possible that the farmer's distrust of the institution will be such that the expected value will be so low that adoption will not take place.

The results of a study of small farmers in Cartagena, Costa Rica are reviewed. It is shown that there is a positive relationship between adoption of an innovation and trust (confidence) in the institutions involved.

The paper concludes that investments in improving institutional capabilities are advocated as they will lead to better institutional performances (increased adoption of practices by farmers).

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By

S. Kenneth Shwedel

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> Don't gamble unless you can afford to lose, and if you can afford to lose, you don't have to gamble.
>
> Detroit Free Press
> March 20, 1973

Rural development as a policy in the less developed countries (LDC) has received increased attention and analysis in the last decade and a half. The growing awareness that total integrated economic development will be based on a strong rural economy has resulted in more resources and effort being channeled into the agrarian sector. This represents a departure from the traditional policy of "milking agriculture dry" to finance development in the other sectors. Given that the status quo is viewed as a state of stagnation, rural development becomes a process of directed change (inducing innovation). This process may be thought of as a program which tries to induce large numbers of individual farmers to adopt a given innovation[1/] into their established behavioral patterns or practices.

Unfortunately, many attempts at rural development through directed change have failed, or at most, not accomplished all that

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1/ An innovation is considered as any change from the established farming practices; it does not necessarily have to be new or unknown to the farmer. The concept need not be constrained by the degree of change; thus an innovation may be a very radical or a very slight change.

was desired. Efforts to justify these failures have often led to criticism of the small peasant farmer. He is said to be ignorant, irrational, uneconomical, culture-bound, <u>bruto</u>, etc. 2/ [26] It is the contention of this paper, however, that far from the above, the peasant farmer is indeed a very rational being and, as such, his rejection or acceptance of an innovation can be explained, with a few slight changes, by the traditional tools of economic theory.

The process of adoption is seen as essentially a decision-making problem. As the farmer becomes aware of the innovation he must make a choice: 1) accept; or 2) reject. Of course, the two choices are neither absolute nor final; they are subject to degrees of intensity, and revokable. What is critical, however, to the process of adoption is the decision-making rule used to evaluate the alternatives associated with the choice of either accepting or rejecting the innovation.

This paper shall suggest the use of decision theory and the desire to maximize expected von-Neuman Morgenstern utility as the decision-making rule. It will be shown that in the context of this traditional economic concept the small peasant farmer's responses and choices are those of an "economic person" attempting to maximize this valued commodity. Finally, believing that to be useful, a theory must have practical application, there will be a

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2/ This opinion is shared not only by many low level change agents, but also by many scholars, researchers, and policy makers. Dr. N. Borlaug, Nobel Prize winner, in a lecture at Michigan State University in 1971 stated that the peasant farmer needs to <u>see</u> an increase of 200 - 300% before he can be induced to adopt a cropping innovation.

discussion of the implications of such a theory to development policy _vis-a-vis_ the process of adoption of innovations.

Utility and Decision Making

Each and every day the peasant farmer faces a myriad of situations and problems which require him to make a decision authorizing or rejecting different sets of actions and alternatives. The situation may be simple and familiar. For example, he must decide whether to drink his coffee black or with milk. Or, they may be complex problems such as a decision to join a new cooperative. Whether the decision is one of drinking coffee with milk or joining a cooperative, the farmer goes through a process of setting up alternatives, determining consequences and establishing probabilities.[3/] If the farmer has faced this situation before, the decision will be based on past experience and known preference. The decision to drink his coffee black may be considered as decision-making under certainty: "all relevant information is known in advance: the solution to the problem involves a search through all alternatives to find the optimum one." [28, p. 189] Given the initial decision to drink coffee, the alternatives are: 1) to use milk; or 2) not to use milk. Seeing that he receives more satisfaction not using milk, the coffee is drunk black. On the other hand, if this is the first time, or if circumstances have changed since the last time this situation had presented itself,

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3/ This, of course is not meant to imply that the two decisions are of equal importance, nor that the time spent on each is equivalent.

the farmer will nevertheless go through the same process of setting up alternatives, determining consequences, and establishing probabilities, only now he cannot be sure that all the variables or their consequences (values) are known (decision-making under uncertainty). The probabilities are considered as subjective probabilities: "The probabilities associated with a given value are unknown." [28, p. 201] Although the farmer is dealing with uncertainty he must decide upon a course of action. It should be noted that even the decision not to decide is a decision with a resulting action (not acting) and a set of consequences. 4/

Attempts at directed change through the introduction of an innovation creates a new situation forcing the farmer to make a decision. The process by which the decision is made is the heart, or essence, of the adoption question. Numerous studies on the characteristics of adoptors only tell us who is most likely to adopt an innovation. [8, 9, 15] The concern of the change agent is to induce adoption and, as such, he needs to know how and why each farmer makes his decisions regarding innovations. The fact that large farmers are more likely to adopt an innovation is of little use to one who works in the LDC where small farmers predominate. It is the decision-making process which finally tells each individual farmer whether or not to adopt the innovation. It is for this reason that the decision-making framework is valuable to the

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4/ Bradford and Johnson list five knowledge situations: 1) inactive; 2) learning; 3) forced action; 4) subjective risk; and 5) subjective certainty. The first two are associated with no-action responses. [3, p. 373] study of adoption and innovation in rural development. The decision-making framework offers another advantage in that it is a 'clean' theory, that is, there are not many lose ends waiting to be tied together. Finally, using this as the theoretical approach to adoption facilitates multi-disciplinary cooperation so important in dealing with socio-economic phenomena and change.

Decision-making then is the process of setting up alternatives, determining consequences, establishing probabilities, and finally choosing a course of action. In order to choose, or decide upon a course of action, there must exist some way to measure and select among the alternatives. This is the decision-making rule. People normally elect that alternative which provides them with the most satisfaction or pleasure, or conversely, the least displeasure. Stated in more exact terms, the decision-making rule requires one to select that course of action which maximizes his expected satisfaction. Since many of the decisions that the peasant farmer makes eventually affect his total wealth, it is safe to assume that there is a relationship between satisfaction and wealth. That is, for each farmer, differing levels of wealth are associated with differing amounts of satisfaction. von-Neuman Morgenstern utility is an abstract concept which, when applied to wealth, refers to the usefulness or satisfaction received from a given level or amount of money. [2] Using utility, the decision-making rule may be rephrased to read: "decide upon that course of action which maximizes expected utility."

It now may be hypothesized that the peasant farmer upon being presented with an innovation decides whether or not to adopt it on the basis of maximizing the expected utility associated with the wealth levels of various alternatives.

DECISION RULE

At this point, it may be worthwhile to review the selection of utility maximization as the decision-making rule for the adoption of innovations. Other determinants of adoption have been suggested. The one most frequently heard is the cultural constraint, but as Victor Uchendu concludes after a review of various models:

> These five models have their uses; but as theoretical tools in the hands of a student of economic development, their limitations are obvious. We cannot say on the basis of any of these models what will be the likely response of a given society to a given set of innovations, or, put in another way, what set of innovations or programs of directed change will succeed in one area and not in another. [29, p. 228]

This is not to deny the importance of the cultural factor in the process of adoption. Nor does this imply that maximization of expected utility is an absolute rule; it too is subject to constraints, modifications, and limitations. It is believed, however, that it has a wider applicability and thus, not hindered by the restrictions of other models.[5/]

Wealth as the utility measurement has long been an acceptable

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5/ Although it will not be dealt with in this paper, cultural and social practices may very logically be incorporated into the utility maximization framework. This would be accomplished by letting utility be a function of not only wealth, but also of social and cultural pressures. For example, an increase of wealth achieved through a socially unacceptable practice may cause repercussions to the gainer resulting in the amount of satisfaction or utility associated with that new level of wealth to be lower than his initial level of utility. Thus the rejection of an innovation due to cultural inhibition would be explained within the utility maximization theory.

economic concept, and it is consistent with the goals and desires of the peasant farmer. Money, it should be noted, has not use in and of itself; rather, its usefulness is derived from its convertibility to possess a desired commodity or gain control over a fixed resource.[6/] It should be further noted that wealth may be calculated in terms of money or resources. It is this convertibility that makes wealth such a useful tool in the decision-making process. For example, Cancian in his study of a Mexican Indian village finds that resource control is very important to the rank of each individual in that society. Since it is assumed that people prefer a higher rank to a lower rank, they will manage their resources to achieve the highest possible rank [4, p. 136-137]; wealth is used as the decision-making rule through which utility is maximized.

Having established the utility of wealth as the decision-making rule, the logical question is: "How useful are different levels of wealth and incremental change in wealth levels to each individual?" In other words, how much satisfaction is derived from each level of wealth? The satisfaction is based on each person's subjective system. For example, a $10 addition to total wealth (T.W.) means more to someone whose T.W. is $100, than to another person whose T.W. is $1,000. This last point is very important: absolute changes in T.W. stimulate different amounts of satisfaction in different people. This is the main reason for using utility of wealth as the

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6/ Keynesian economics postulates two types of money: 1) speculative; and 2) transactions. Both refer to the process of achieving present or future control over some commodity or resource.

decision-making rule, rather than something similar to benefit-cost analysis, or comparing incremental changes in T.W.[7/]

The relationship between utility and wealth may be described by the use of a utility function relating the different levels of wealth to corresponding levels of utility. Although each individual has his own special relationship between wealth and utility, it is nevertheless possible to construct a general utility function, just as it is possible to construct a general production function representing different plots of land. von Neuman and Morgenstern pioneered a methodology that can be used to construct the utility function. Starting out with five assumptions: 1) transitivity; 2) continuity of preference; 3) independence; 4) desire for high probability of success; and 5) compound probabilities [2, pp. 521-522], an individual is given a choice between A with certainty or a lottery ticket with prizes of either B or C. Now, suppose that he can win B with probability P, and C with probability (1-P). Associated with A, B, and C are their respective utilities U(A), U(B), and U(C). The utility of the lottery ticket U(L) is the probabilities of B, and C, and their utilities:

$$U(L) = P[U(B)] + (1-P)[U(C)]$$

7/ The use of maximizing expected utility [Max E(U)], rather than maximizing expected T.W. as the decision-making rule leads to different solutions to the same problem when there is uncertainty. Consider the above example: if T.W. were to be used as the criterion both individuals would adopt the innovation since it would add $10 to their T.W. Looking at the $10 as a percentage of T.W., for the poorer individual this represents 10% of his T.W., while for the other it is only 1% of his T.W. If the amount

If A is preferred and chosen to the lottery ticket $(L = PB + (1-P)C)$, it implies that:

$$U(A) > U(L)$$

or

$$U(A) > PU(B) + (1-P)U(C).$$

At this point there is a crucial step which assigns values to U(B) and U(C).[8/] For example, let U(B) = 10 and U(C) = 100. Now the probabilities of B and C are varied to the point where the individual is indifferent between U(A) and U(L):

$$U(A) = P^*U(B) + (1-P^*)U(C)$$

From the above, knowing P*, U(A) can be calculated. If, for example, it was found that the individual was indifferent between U(A) and U(L) when P* = .7, then U(A) = 37 [= .7(10) + .3(100)]. By repeating this same procedure many times, varying the values of A, and the probabilities of B and C, the individual's utility function is constructed.

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of satisfaction is proportional to relative changes in T.W., the poorer individual would face the possibility of a large gain in satisfaction, while the other (richer) individual would be, more or less, indifferent in the face of a small change in his level of satisfaction. Thus, in this case, using T.W. as the decision-making criterion both would adopt the innovation; however, if utility were to be used it is very likely that one would adopt the innovation and the other would not.

8/ Usually B and C are chosen to represent two extremes, i. e., B = $0 and C = $1,000,000, or as Baumol uses, B is damnation and C is eternal bliss. [2, p. 517]

Although each individual's utility function is different, the general shape of a utility curve will be that shown in Figure 1 (p. 11). This again is similar to the production function which is different for each plot of land, yet its general shape is well known. Inherent in the shape of the utility function are certain assumptions and observations of which one should be aware. First of all, each successively higher level of wealth is associated with a higher level of utility. Secondly, the rate of change of utility (marginal utility) is not constant. In area I, for example, it is increasing at an increasing rate, while in area II it is increasing at a decreasing rate.[9/] This phenomenon can be better understood with the aid of Figure 2 (p. 12). On the vertical axis is the minimum probability of winning at which one would place a bet. The horizontal axis represents the possible gains from such a wager. It is seen that within a nominal range the higher the gain, the lower are the minimum odds. One additional factor affects the minimum odds. This is the size of the stake. The larger the stake, the higher the odds must be in order to induce the wager. If the size of the stake were expressed in relative terms, it is seen that the same absolute amount varies in relative size according to its percentage of T.W. Thus, what may be a relatively small stake to a person at point E on Figure 1 (S_2 on Figure 2), is rather large to the person at D (S_1 on Figure 2). As such, even though

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9/ More precisely: $U = f(W)$, and $0>f''(W)$ in area I; in area II $f''(W)>0$.

UTILITY FUNCTION

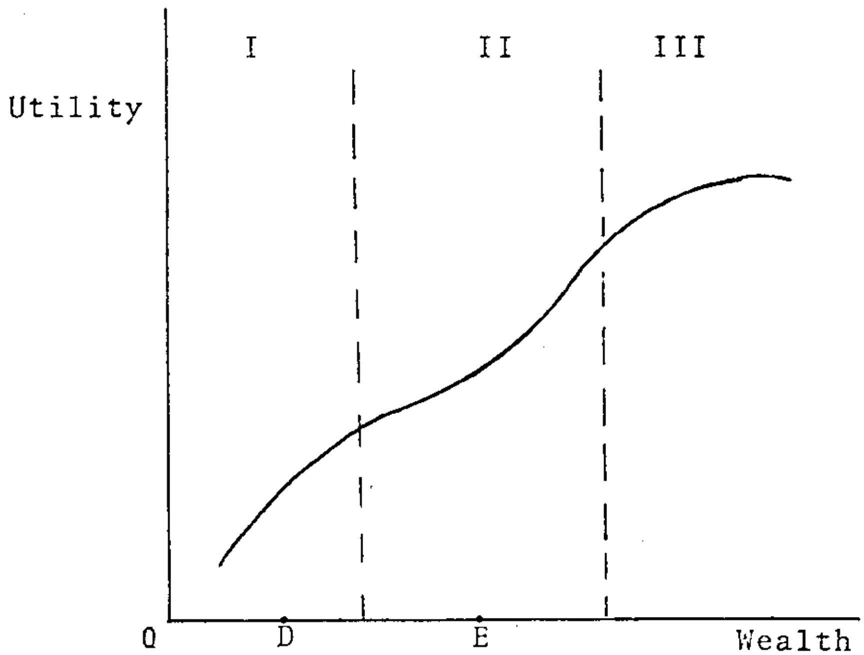

Figure 1

PAYOFF PROBABILITIES *

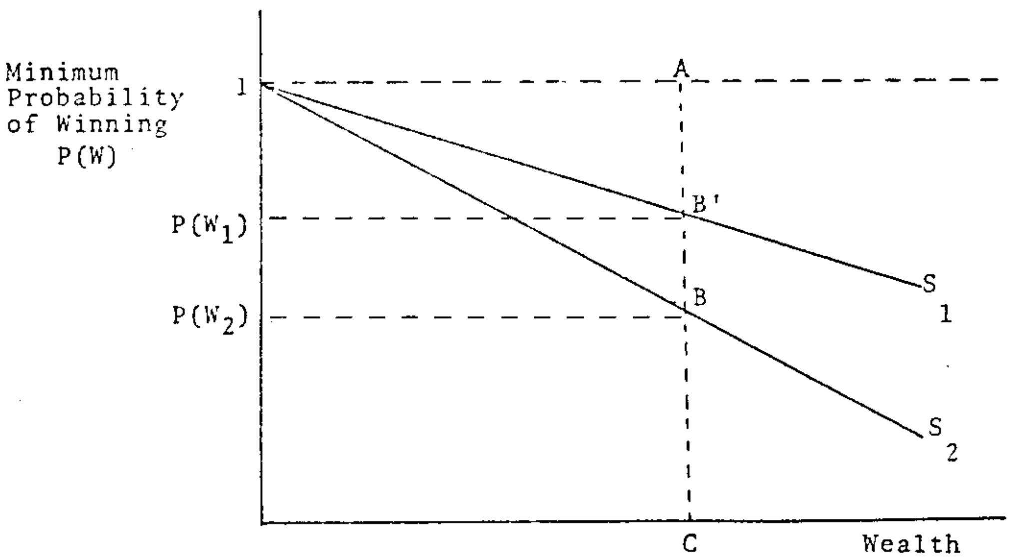

Figure 2

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* It can be shown that the utility at 1 unit of money gain is the ratio BC/AB. Assume that a 1 unit stake has a utility of 1 util, thus "BC times the utility of one money unit's worth of gain is the same as one minus BC times one utile... Hence the utility of the gain of one money unit is one minus BC divided by BC, and this is the ratio AB/BC." [7, p.88] Noting that the ratio AB/BC > AB'/B'C, it is seen that the line becomes "curved" to reflect the changing marginal utilities associated with different levels of wealth.

the money gain remains constant, the minimum probabilities are different. This is reflected by the changing rates of marginal utility associated with different levels of wealth. Finally, this utility curve may be considered an 'aggregate' utility function with the population being divided into three broad groupings: 1) poor; 2) middle; and 3) rich, corresponding to areas I, II, and III respectively. This point shall be treated at a later stage in this paper.

Utility and Adoption

In the above discussion, in order to construct the utility function the individual was made to choose between A or the lottery ticket. The mechanics of the choice were not included in that discussion; this will be dealt with in the present section.

Friedman and Savage [11], in their classic article, attempted to use maximization of expected utility as the decision-making rule to explain the choice between insurance (the A above) and gambling:

> In choosing among alternatives open to it, whether or not these alternatives involve risk, a consumer unit (generally a family, sometimes an individual) behaves as if (a) it had a consistent set of preferences; (b) these preferences could be completely described by a function attaching a numerical value -- to be designated "utility" -- to alternatives each of which is regarded as certain; (c) its objective were to make its expected utility as large as possible. [11, p. 103]

The individual is said to have two alternatives. The first, A, whose outcome is known to be certain is represented by the income I_0 in Figure 3 (p. 14). The other alternative, L, involves a chance

UTILITY FUNCTION FAVORING INSURANCE

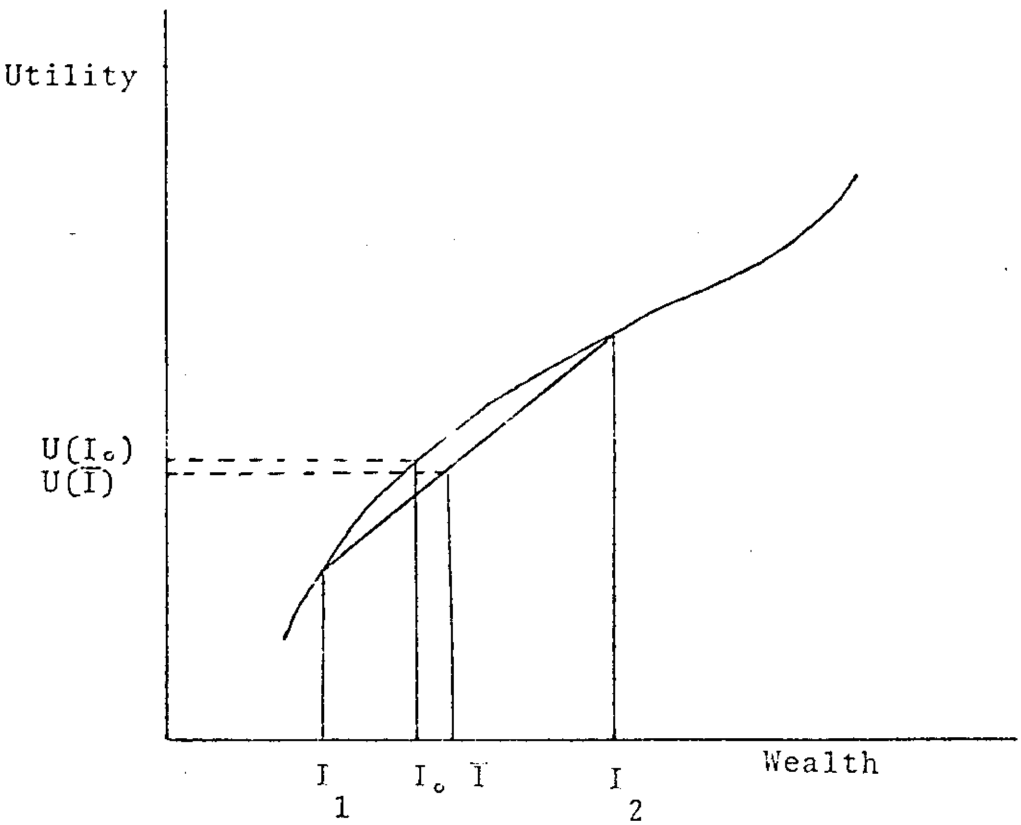

Figure 3

or risk of probability P ($0 < P < 1$) of an expected income of I_1 and a chance of (1-P) of an expected income of I_2. Additionally, it is stated that I_2 is always greater than I_1. The expected value for the gamble ($E(\bar{I})$) is:

$$E(\bar{I}) = PI_1 + (1-P)I_2$$

The expected utility from the gamble L is:

$$EU(\bar{I}) = PU(I_1) + (1-P)U(I_2).$$

Since this is, in reality, the weighted average of the utilities of the two alternatives, the $U(\bar{I})$ will lie above $\bar{I}$ on the chord which connects $U(I_1)$ and $U(I_2)$.

In this example, although the expected return from gambling ($\bar{I}$) is greater than I_0, the utility of being insured $U(I_0)$ is greater than the expected utility of the gamble, $U(\bar{I})$. Thus it becomes perfectly logical and consistent for the individual to choose A although his expected income will be less than if he had gambled.

In Figure 4 (p. 16) the situation is reversed. Although the expected income from the gamble is less than the sure income, the individual nevertheless chooses to gamble. In this case, however, $U(\bar{I})$ is greater than $U(I_0)$, also making this decision logical and consistent within the framework of the decision-making rule.

The Friedman-Savage hypothesis is based on observed human behavior. It does not say that the individual sits down with pencil and paper in hand to calculate the expected utility. Rather, it states that individuals act _as if_ they calculated expected utility.

UTILITY FUNCTION FAVORING A RISK

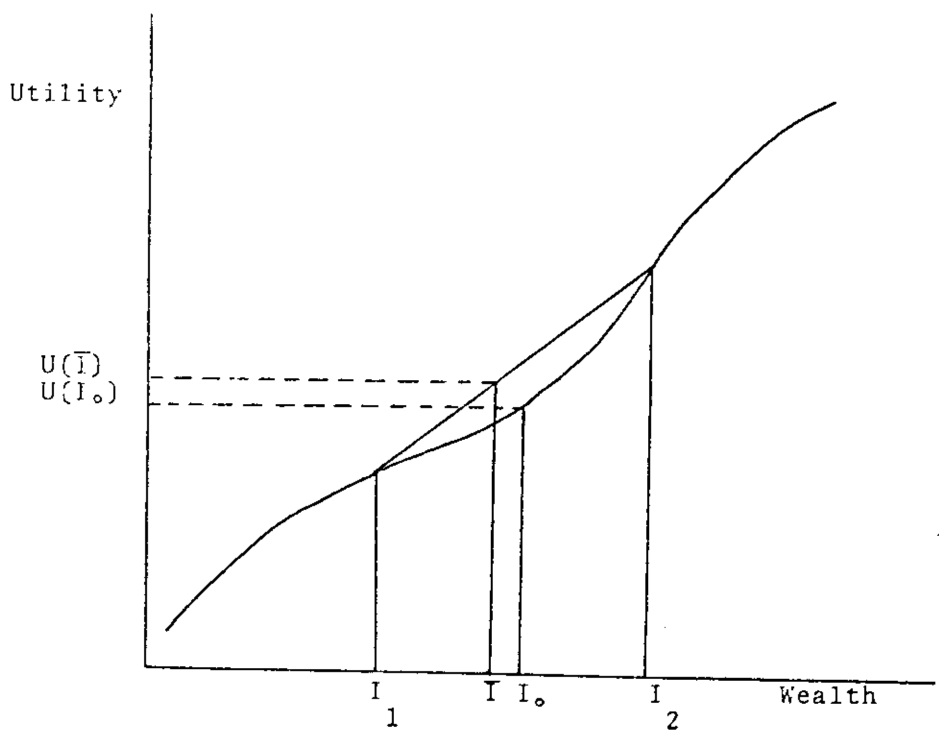

Figure 4

The fact that they act this way gives credence to the idea that by changing the estimates of the expected outcomes and probabilities, the decisions would most likely be different [see 22].

Up to this point, the discussion of utility and wealth has centered around gambling and insurance. Instead of gambling, let us now consider adoption. This is not as radical a suggestion as it may appear. The adoption of an innovation is, in a sense, a gamble. It involves a stake, usually an amount of land, labor, and/or other inputs that are applied in connection with the innovation -- the wager, or gamble. Like gambling, the adoption of an innovation has more than one possible price or outcome. Finally, adoption, similarly to some forms of gambling, is usually not a fair bet.[10/]

In place of insurance consider an established practice whose outcome is well known as the result of long periods of use within the equilibrium state of the traditional agriculture of the area. Economically, the established practice usually represents an efficient state:

> ... the combination of crops grown, the number of times and depth of cultivation, the time of planting, watering and harvesting, the combination of hand tools, ditches to carry water to the fields, draft animals and simple equipment -- are all made with a fine regard for marginal costs and returns. [27, p. 39]

10/ A fair bet is one where the expected net gain over a long series of wagers is zero. [1]

In agriculture nothing is riskless; but for the farmer, the established practice represents a state of minimum risk. Since this practice by definition has existed for long periods of time, the expected outcome is equal to its mean value,[11/] and thus may be considered a constant. The events of the previous period, such as favorable weather conditions, the failure of inputs to be available, etc., will have no distinguishable effect on the calculated output of the established practice used in the present period.

In a similar manner, there is an expected price $[E(P_t) = \overline{P}]$ which, when applied to the expected output $[E(O_t)]$, will yield the expected return to the established practice. This may also be considered as a constant value, expressed as a fixed level of wealth $[E(O_t) \cdot E(P_t) = \overline{W}]$. The innovation, on the other hand, due to its state of uncertainty, will be characterized by the possibility of different expected returns in each period, or in other words, different levels of wealth.[12/]

As mentioned above, there is a singular amount of utility which corresponds to each level of wealth. Combining the two, the Friedman-Savage model may be adapted to explain the rejection or adoption of induced innovations. Letting I_0 stand for the expected income, or return to an established practice $(I_0 = \overline{W})$, and I_1 and I_2 represent the possible returns to an innovation with probabilities of P and (I-P) respectively, Figures 3 and 4 may now be used to interpret adoptive

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11/ Where O_t = output in year t, then $E(O_t) = \overline{O}$.

12/ For the purpose of this paper there will be only two possible outcomes, complete success or complete failure from the adoption of an innovation. This simplifies the discussion without sacrificing the explanatory power of the theory.

patterns. In Figure 3, the expected return from the new innovation ($\bar{I}$) is greater than the expected return from the established practice, yet the farmer who attempts to maximize utility would reject the innovation. Figure 4 represents the case where the innovation will be adopted since its expected utility is greater than the utility corresponding to the established practice.

It is at once noticed that the probability of adoption is directly related to the shape of the utility curve. In Figure 3, the chord from which the utility of the innovation is calculated lies below the utility function, while in Figure 4 it lies above the utility function. Rather than suggesting that the graphs are 'fixed', if one remembers that the utility curve is a function of relative wealth, satisfaction from additional wealth, and disatisfaction from the loss of wealth, it becomes clearer that the utility function reflects different social classes:

> ... the two convex segments as corresponding to qualitatively different socio-economic levels, and the concave segment to the transition between the two levels. [11, p. 116]

Area I would represent the poor peasant farmer who, if he were to adopt an innovation, must put a <u>relatively</u> large stake due to his limited level of wealth. His reluctance to adopt the innovation is probably due to the fact that marginal utility decreases at an increasing rate, causing him to fear I_1 more than to favor I_2. Area II is the middle ground; it is the period of consolidation and chance. It may be assumed that those in area II still close to the boundary of area I will be less willing to adopt since I_1 would most likely fall in area I. This is what is meant by consolidation; they fear failure, and moderate success will not bring a large marginal increment to their utility. The closer the farmer is to area III, the more likely he will adopt an innovation. The utility of being 'rich' outweighs the possibility of a loss, causing its expected utility to be greater than the expected utility of the established practice. Finally in area III, again, the rate of adoption would be expected to be low. In this area even an innovation which would be regarded as a fair bet would be rejected, since the consequences, or utility of loss, outweigh the expected gain.

> In a society with traditional consumption patterns, innovation that gives only modest increases in production may be unlikely to be accepted on the large, more prosperous farms because they are already operating at a point at which marginal utility of additional production is very low. At the other extreme, it is likely that farmers very close to the biological subsistence level attach such high risk premiums to innovation that they are unlikely to try such innovations. Under such circumstances, the most likely group to innovate is the group of farmers who have attained the biological subsistence level but still evidence relatively high utility to additional income. [19, pp. 173-174]

DISSIMILAR OUTCOME PERCEPTION

Up until this point, the outcomes (I_1 or I_2) of an innovation were considered as being the same by all those involved in the adoption process. This need not be the case, and indeed, more often than not, the perception of the outcomes varies from individual to individual.

Consider a cropping innovation, say the use of a hybrid seed, and three different people involved in the innovative process: (1) the researcher; (2) the change agent; and (3) the farmer. Leaving I_1 constant, the perception of I_2 will be different for each person, which will, in turn, result in different choices while using the same decision-making rule. The researcher conducting his experiments under perfect conditions, concludes that the innovation would yield I_2 in Figure 5 (p. 22) with utility equal to $U(I_2)$. The change agent introduces the innovation on a demonstration plot. Using not so perfect conditions, he suggests to the farmers a return equal to I'_2, having utility $U(I'_2)$. The farmer seeing that the change agent devoted much time and effort, as well as using special inputs not available to him, further discounts the expected return from the successful application of the innovation. He perceives the outcome as equal to I''_2, with utility $U(I''_2)$. In this example, $U(I_2)$ and $U(I'_2)$ are both greater than $U(\overline{I})$, the utility of using the nonhybrid seed. The researcher and the change agent would expect the farmer to adopt the innovation. The farmer, on the other hand, facing a utility of $U(I''_2)$ which is less than $U(\overline{I})$, will decide not to use the hybrid seed.

In the above example, the perception of the gain from using hybrid seeds varied due to discounting because of changing technological conditions (land, supervision, irrigation, etc.). This is not the only reason for differing perceptions of outcomes.[13/] If the innovation requires a scarce input, the

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13/ The perception of the outcome should not be confused with the concept of "the probability of the outcome." The first fixes I_1 and I_2, while the second concerns itself with the chances that the outcome will occur.

UTILITY FUNCTION WITH DIFFERING PERCEIVED OUTCOMES

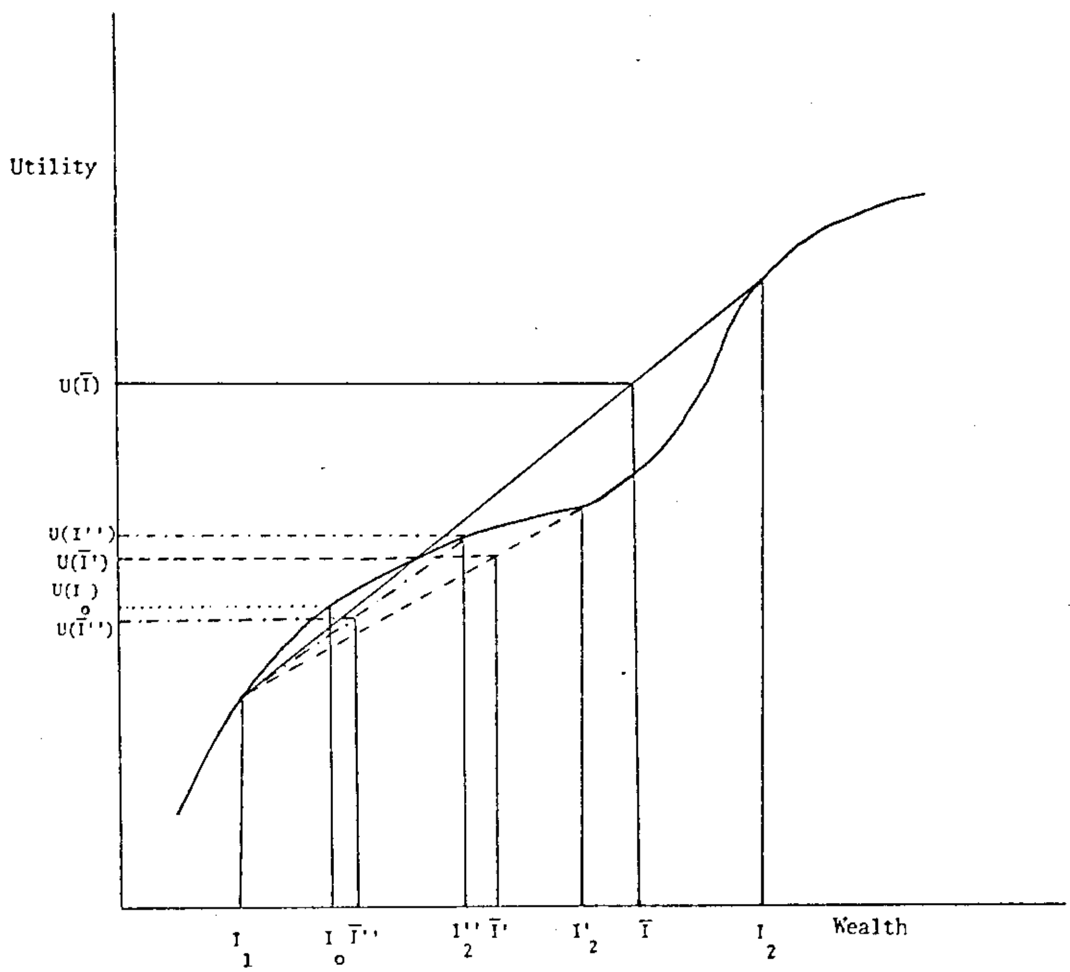

Figure 5

outcome will be different for those who have access to that input as opposed to those who are unable to use it. Also, the source that recommends the innovation influences the perception of the outcome. The farmer who constantly deals with an extension agent whom he trusts is less likely to discount the information than if it had come from someone he hardly knew or trusted. The same is true with respect to institutional relationships. The length of time dealing with an institution, its past performance, and its reputation, all influence the degree to which its information is discounted.

In addition to regarding the perceived innovation outcome as varying throughout the population, the probability of these outcomes will also vary throughout the population and over time. Probability refers to the expectation that a given event will occur; it is expressed as a fraction between, and including, 0 and 1 ($0 \leq P \leq 1$). The determination of probability is based on a frequency distribution, which, in turn, is constructed by use of *a priori* information and subjective judgments. [23, pp. 86-89] As more information becomes available, it is incorporated into the frequency distribution to yield a new set of probabilities:

> Before the evidence is seen, the prior probabilities P(0) gave the betting odds ... But after the evidence is in, we can do better; the posterior probabilities P(0/X) now give the proper betting odds. [30, p. 199]

Subjective judgments also influence the probability set. These are opinions which are not based on direct contact with the innovation in question, but nevertheless influence the determination of the chance of its outcome. In the hybrid seed example, if the farmer in previous years had used other hybrid seeds which failed on an average of once every two years (possibly due to drought), when confronted with a new hybrid he would attach a 50% possibility (P = .5) that his income would be I_2. Likewise, the probability set may be affected by the experience with other inputs which would be needed to utilize the innovation. This relates to both the availability and the cost of the inputs. With induced innovations, the farmer's experience with the concerned institution plays an important role in determining the probability set. If there is little confidence in the institution's promises of inputs of information, its statements of probability regarding the innovation's expected performance are heavily discounted.

Consider the case of a change agent recommending the use of a new mixture of fertilizer. Say that both the farmer and the change agent agree that using fertilizer would yield I_2. The change agent says this outcome is 90% certain; the farmer, however, does not have complete confidence in the change agent. In previous encounters the farmer has found that only 80% of what the change agent says is likely to occur. Further, let the fertilizer be supplied by an institution which, in the farmer's opinion, is only 50% effective. The change agent places the probability of I_2 at .9, and the expected income is $\overline{I}$ in Figure 6 (p. 25). The farmer discounts twice: (.9) X (.8) X (.5), once for the change agent and once for the fertilizer supplying institution; he places the

UTILITY FUNCTION WITH DISCOUNTED OUTCOME

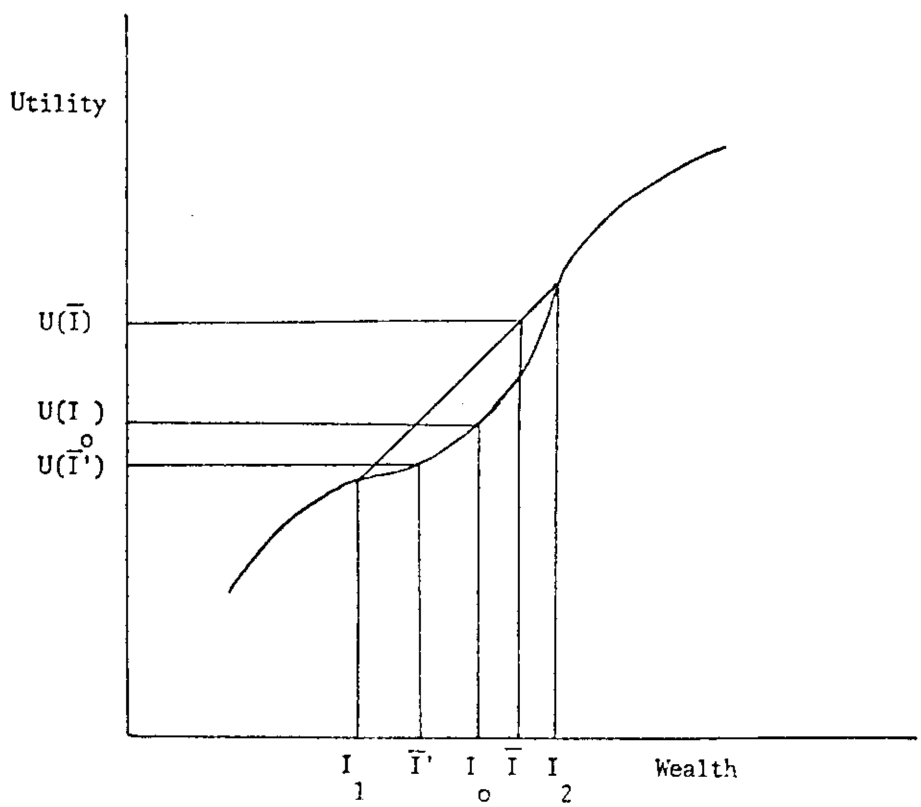

Figure 6

probability of I_2 at .36, and the expected income becomes $\overline{I}'$. This in effect places $U(\overline{I}') < U(I_0)$, which means that the farmer will not accept the recommendation of the change agent.

Utility Decision-Making and Policy

Figure 7 (p. 27) represents an attempt to construct a farmer adoption and feedback system. It shows the processes that the peasant farmer goes through in order to assign values to innovation outcomes, and probabilities to these outcomes. It is divided into four components: 1) inputs; 2) production mix; 3) outputs; and 4) feedback.[14/]

The inputs represent the environment in and through which adoption takes place. Each input influences the farmer's decision regarding the composition of the production mix which is applied to the output. Important to the discussion of the inputs are the farmer's observations and perceptions concerning present, as well as future make-up of these variables. [15, p. 90]

In the model, ecology represents such factors as soil texture, content, ph value, rainfall, etc., of both the farm and the region. These are the factors most relevant for the pure agronomic research. Technical innovations must be based on extensive knowledge of the area's ecology, and therefore, consistent with the limitations imposed by the ecological constraints.

14/ Rogers' five attributes of innovations are built into this model as they influence the probability set: 1) relative advantage; 2) compatibility; 3) complexity; 4) observability; and 5) trialability. [26]

PEASANT [illegible] AND FEEDBACK SYSTEM

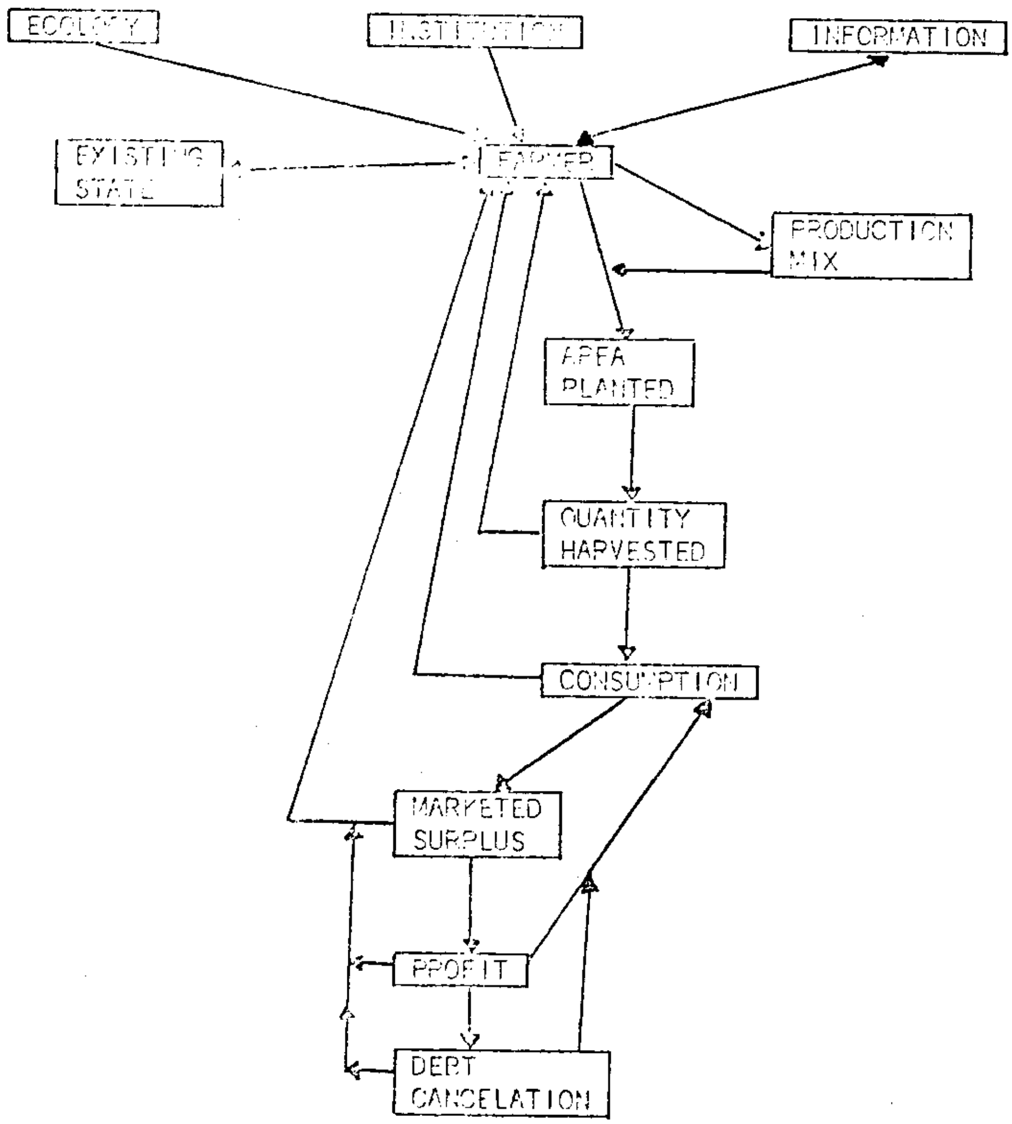

Figure 7

The institution is considered as that organization which introduces the innovation to the area, and presents itself to the farmer as the 'seller' of the package. Although there may exist interrelationships between the institution as an input and the other inputs (credit and knowledge), the main concern of this paper is with the institution as the dispenser of the innovation, and the farmer's perception of the innovation as coming from that institution.

Knowledge is the sum of information that the farmer receives referring to the innovation and the package in which it is "sold". Information may be transmitted by visual, printed, or oral methods. It usually comes from the institution or from other farmers. [8] However, the farmer may also decide to actively seek information regarding an innovation. There is a cost associated with this activity in income and time (opportunity cost). This cost is balanced by the perceived quality of information that is gathered.

Finally, the existing state may be conceived of as a sort of a residual component. Physical properties, such as the size of the farm, machinery, etc., are included in this input. Also included are such concepts as the existing knowledge bank, and estimates of probabilities based on past experience. [15, p. 82] It is worthwhile to note at this time that the existing state receives a feedback output in the form of information based on past experience which, in turn, changes its make-up. This has the effect of completing the system, for once the innovation is adopted, it is considered as part of the existing state.

These different inputs are used to make a priori statements about the innovation. All of the inputs may affect both estimates of the outcomes and the probability of the occurrence of each outcome. In other words, the farmer attempts beforehand to calculate the value of the feedback component. At this point, the farmer is forced to decide whether or not to incorporate the innovation into his production mix.[15/] If he does not, he continues through the system using the established practice. In the next cycle of the system, he will receive an additional 'batch' of information (good or bad) concerning the innovation. This may be from the institution which is attempting to induce the innovation, or from other sources, chiefly fellow farmers. Again, he will have to decide whether or not to include the innovation in the production cycle. This process will continue until either it is absolutely rejected,[16/] or tentatively accepted. If it is accepted, it is incorporated into the production mix and applied to the area planted -- the physical dimensions of the land area to which the innovation is applied.

Related directly to the planted area is the size of the harvest. The size is judged, not so much in absolute quantities, but rather in relative terms. The farmer, from his existing state input, has an idea of what should be the harvest on that area of land. The difference is considered as part of the feedback mechanism.

15/ The production mix is the factors of production that are applied to a unit of land -- machinery, labor, fertilizer, seeds, etc. -- and/or the use of credit to expand the scope of operations.

16/ This is usually associated with a rejection in mass by the farmers

Since the concern is with small farmers, the subsistence component, or the extent to which production adds to consumption, is an important output-feedback variable. [13, p. 32] Consumption, beside being considered as a depleting event on the amount of production available to be sold in the market, is also considered as an acquisition event, i. e., the purchasing of any good by the farmer with the receipts from the innovated crop. Thus, what in other studies is termed investment, here is lumped into the category of consumption. The multiple nature of this category requires that the feedback component consider (1) ability to maintain at least a subsistence level; (2) possibility of a surplus to be marketed; and (3) increase in purchased goods.

What is not consumed on the farm is then available to be sold. This means that there must be (1) a market available for the product; and (2) a price which allows for the farmer to make a profit. The feedback component would, therefore, require information on (1) market availability; (2) price prospects; and (3) actual profit. Profit is included because the availability of a market per se does not mean that the farmer will be better off after selling his surplus product. [27, p. 164] If the price is too low, profit is not made, and this is fed back into the knowledge-risk bank.

The profit, in turn, is channeled into consumption (purchased goods), and into debt cancellation. Since credit is one possible

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in the zone, and the institution's decision to discontinue its attempts at inducing the innovation.

component of the production mix, there may be a debt which must be liquidated before the system is able to complete its cycle. The ability to cancel the debt, and the returns afterwards are considered as the relevant feedback.

These elements which make up the feedback component had, prior to adoption, been estimated by the input component. They now, however, form an empirical knowledge bank which provides the farmer with posterior probabilities [30, p. 199] on which to base future decisions. If the innovation is employed again and again, it becomes an established practice whose returns are calculated not by posterior probabilities but by its mean.

Within the scope of the aforementioned adoption and feedback system, and the previous discussions on utility, wealth, and adoption, it becomes apparent that attempts at inducing the adoption of an innovation should be concerned with those activities which influence the perception of outcomes and the estimation of probabilities,17/ or with reducing risk. Basically, these activities may be subdivided into those which reflect upon the nature of the innovation, and those which deal with the inducers of the innovation.

The innovation should be designed for the area in which it is to be applied. This involves an understanding of both the ecology and existing state that affect the farmer. The innovation should be such that the farmer's possible loss outcome will be minimized, especially in the initial periods of adoption. The loss involved

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17/ The author does not doubt the shape of the utility function may be changed, or the function itself shifted. However, due to the nature of the utility function and the way it is constructed, attempts at changing it are seen as long-term programs involving changing attitudinal behavior.

in employing an innovation can be broken down into two parts: 1) the loss of the value of the inputs used -- this includes the cost of labor, depreciation, interest on debts incurred, etc.; and 2) the opportunity loss -- this is equal to the value of production of the inputs if they were used in a different activity. It is obvious that the larger is the proportion of total resources the innovation commands, the larger will be the expected loss. In Figure 8 (p. 33), I_1 and I_2 represent the expected loss and gain from a large portion of the farmer's total resources being used with the innovation. I'_1 and I'_2 represent smaller outcomes due to a smaller proportion of the farmer's total resources being tied up with the innovation. It is noted that adoption would occur only in the second case where $U(\bar{I}')$ is greater than $U(I_0)$.[18/]

Throughout this paper it has been assumed that the innovation added or detracted from T.W., but wealth is only a surrogate measure of wants and desires of the farmer. This means that other factors may influence the expected outcomes. If the peasant farmer lives near the biological subsistence level, the expected loss (I_1) would lie further to the left. An awareness of these subjective losses would suggest that the innovation include some factor, or be tied into an additional activity which would serve to arrest these fears.

Finally, it should be stated that a 'good' innovation will eventually be adopted. The rate of adoption is seen as depending on

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18/ This is what is commonly referred to as divisibility of inputs.

UTILITY FUNCTION WITH SIZE AFFECTING OUTCOME

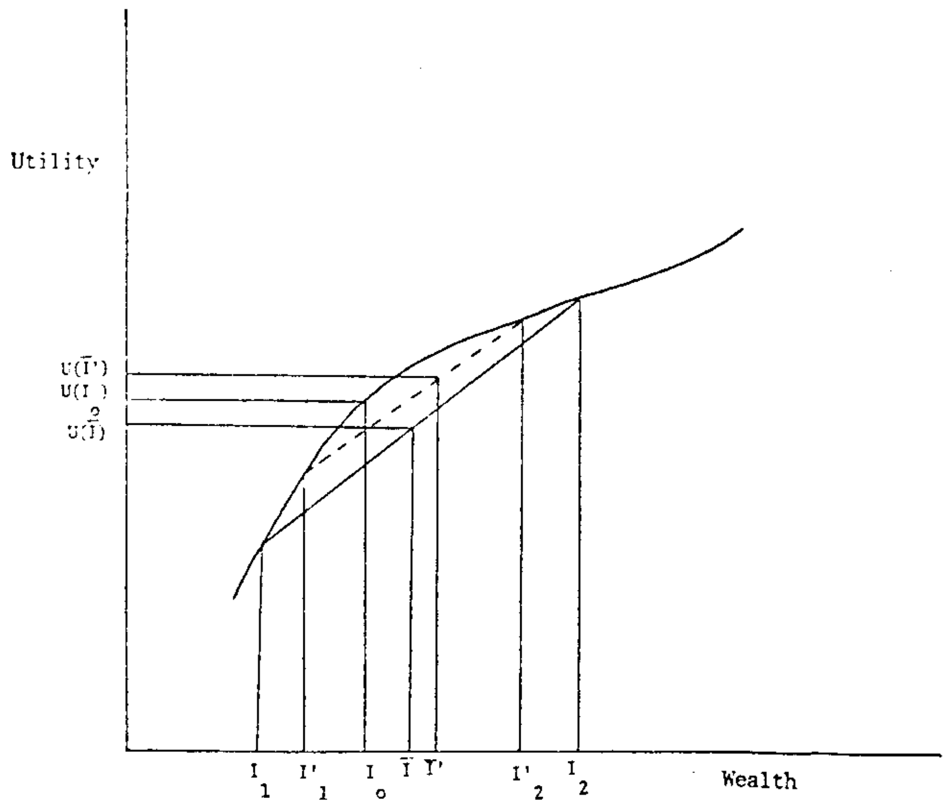

Figure 8

the probabilities of the expected incomes which, in turn, are largely influenced by the institutions which are trying to induce the innovation.

In the example used on the previous page, it was seen that the farmer's degree of trust and confidence in the institution influenced the probability set which he used to calculate the expected utility. The instituion that maintains the farmer's confidence is likely to be able to induce, more successfully, different innovations. This implies that an institution which devotes some of its resources to improving its efficiency and building trust with the farmers will be better able to fulfill its rural development goals. Carried to the extreme, it means that a 'fair' innovation suggested by a trusted[19/] institution will be adopted before a 'good' innovation coming from a usually incompetent institution.

Secondary instituional arrangements must also be considered. These are relationships with institutions which, while not inducing the innovation, nevertheless supply inputs needed for the innovation, or in some other way, affect the probability of the outcomes. Beside the fertilizer example mentioned above, there are numerous other institutions involved with supplying inputs. Among the more important are credit institutions. A farmer who calculates, on the basis of past experience, that there is only a 10 percent chance of the credit being available when it is needed will require a high expected gain and very low expected loss to even consider adoption.[20/]

19/ Trust implies more than just being friendly. It is a statement of belief that results from favorable and honest experiences over a reasonable length of time.

20/ If he views the credit with a 10 percent chance, P = .1, then

Post-adoption activities and institutions must also be carefully considered. With a cropping innovation in a market economy the location of I_2 is influenced not only by the yield, but also the price probability at which the yield is sold:

> Despite all that has been written to show that farmers in poor communities are subject to all manner of cultural restraints that make them unresponsive to normal economic incentives in accepting a new agricultural factor, studies of observed lags in the acceptance of particular new agricultural factors show that lags are explained satisfactorily by profitability [27, p. 164].

When one considers all the institutional problems which face the farmer and affect his probability set, the statement by Dr. Borlaug in footnote 1 begins to take on a different perspective. The farmer needs a 200 percent or 300 percent increase in order to overcome the unfavorable odds attached to the innovation. In the decision-making context, with utility as the decision-making rule, the farmer's actions are really those of a rational economic being. Attempts to change the probabilities and outcomes, notably through institutional change, will result in different levels of utility and changed patterns of adoption.

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even if the outcome otherwise is 90 percent certain, the final weight that is attached to I_2 is P = (.09), or in other words, only a 9 percent chance that he will receive the income.

APPENDIX

The main thrust of this paper has been an attempt to show theoretically that what appears to be an irrational rejection of a given innovation is really a reasonable response when utility is used as the decision-making rule, and projected outcomes and probabilities are allowed to vary. The importance of this, or any theory, especially those relating to development, is in their applicability to a relevant situation. To examine in an empirical setting some of the implications of this paper data was used from the Small Farmer Survey of an AID-funded study on agricultural administration. The survey was designed by Dr. Garland P. Wood of Michigan State University's Department of Agricultural Economics to test the response of small farmers to a sectoral loan program. The sample comprised 35 randomly selected loan-participants, and 10 purposefully selected non-participants in the municipality of Cartagena in north-west Costa Rica. The interviews were conducted over a two month period from September to October, 1972.

The Innovation

While borrowing is not a new practice for the small farmer in Costa Rica, institutional loans due to their rigid and impersonal nature represent a new addition to the traditional farmer's existing state of available inputs [see p.29]. Viewing an institutional loan as a new practice, or innovation, it should be expected that its use would vary proportionally with the farmer's level of wealth. Part of this is undoubtedly related to the institution's reluctance to deal with poorer farmers. Nevertheless, this relationship is also explained by the differences in each farmer's perception of the possible outcomes from institutional borrowing. This, in turn, affects their willingness to apply for an institutional loan.

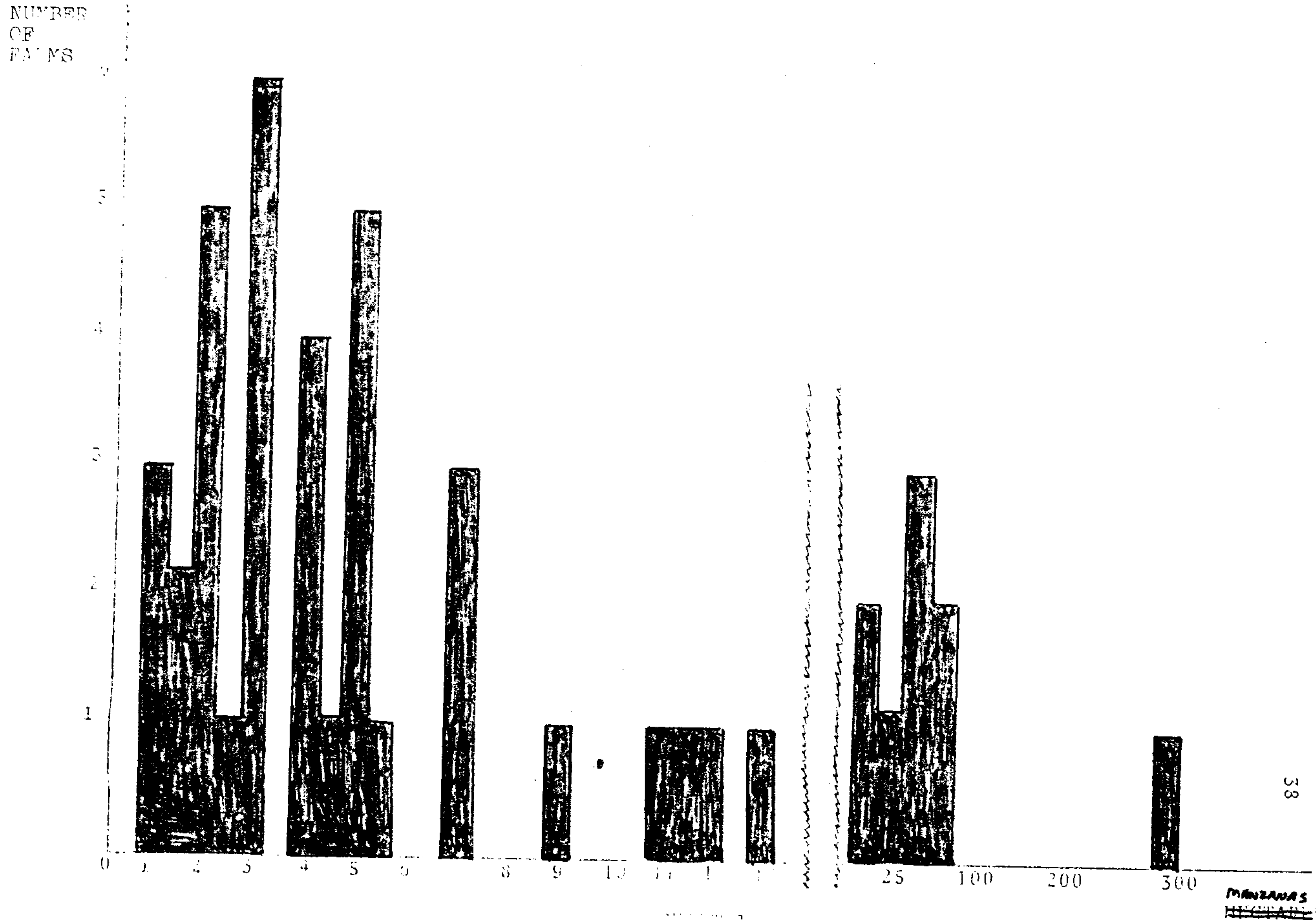
Using total farm size [rented and owned land] as a surrogate for wealth, the 45 respondents were sub-divided into three groups. The groupings were based on the distribution of the farm sizes in the sample [Chart 1, p.38]. The first group included all those with farms (n = 17) up to 3.5 manzanas; the second group (n = 15) was comprised of those with farms from 4 to 9 manzanas; the third group (n = 13) represents all those working farms larger than 9 manzanas.

Table 1 shows the average number of years that each group has received an institutional loan. The wealthiest farmers have been borrowing 5 years longer than the intermediate group. The smallest farmers, it appears, have only just begun to receive institutional

AVERAGE YEARS OF INSTITUTIONAL BORROWING BY GROUP

GROUP	I	II	III
YEARS BORROWING	2.1	4.7	9.7

Table 1


NUMBER
OF
0
1
2
4
5
8
9
25
100
200
300
MANZANAS

loans. The relationship between wealth and adoption is further highlighted when the five largest farmers in the sample are viewed separately: they have been borrowing for an average of 16 years.

The information from Table 1 appears to establish the connection between wealth and institutional borrowing. This data also suggests that the three groups roughly correspond to the socio-economic divisions shown in Figure 1 [p.11]. For Group III, institutional borrowing is now part of their established practice, and no longer represents an innovation. They are the largest, and, as such, the wealthiest group. More than any others, their income is solely from farming[1/] (Table 2).

PERCENTAGE BY GROUP ENGAGED FULL TIME IN FARMING

GROUP	I	II	III
% OF FULL-TIME FARMERS	12.5	26.7	33.4

Table 2

Group I is the poorest of the three. Of the total land used by the respondents in the study, only 4.7% is farmed by this group (Table 3). Only one person reads the newspaper daily, while 7 do not read newspapers at all (Table 4). It is in the second group where most of the innovation should take place as they try to advance to higher socio-economic levels. Using the amount of rented land as an

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1/ This refers to self-employed farming.

PERCENTAGE OF TOTAL LAND FARMED AND SAMPLE POPULATION BY GROUP

GROUP	I	II	III
% OF TOTAL LAND	4.7	10.5	84.8
% OF POPULATION	37.7	33.3	28.8

Table 3

NUMBER, BY GROUP, OF RESPONDENTS WHO DO OR DO NOT READ NEWSPAPERS

GROUP	I	II	III
NUMBER: READ PAPER DAILY	1	3	2
NEVER READ PAPER	7	3	4

Table 4

additional measure of the willingness towards risk-bearing, Group II appears to be the most prone to innovation and risk -- gambling (Table 5).

AREA AND PERCENTAGE, BY GROUP, OF RENTED LAND

GROUP	I	II	III
MANZANAS RENTED	1.35	3.3	2.23
% OF TOTAL RENTED LAND (+ 100%)	22.0	48.7	28.5

Table 5

Outcome Perception

The fact that one group seems more willing to adopt and innovate cannot solely be explained by a desire for socio-economic advancement. It should be noted that the costs and availability of the input mix vary from group to group. These differences influence the calculation of probable outcomes by each group for the same production practice.

FARM ACCESSIBILITY BY TRUCK IN WET SEASON, BY GROUP*

GROUP	I	II	III
TRUCK DISTANCE FROM FARM IN WET SEASON (KM.)	.7	.6	1.5

Table 6

*One farmer in Group III reported 12 Kms. Excluding this response the average distance for the group is reduced to .6 Km.

FARM ACCESSIBILITY IN CAR, BY GROUP

GROUP	I	II	III
% OF FARMS THAT CAN BE REACHED BY CAR	41	60	38

Table 7

Tables 6 and 7 show that Group II is in a more accessible location. This suggests that they face lower transportation costs both to bring needed inputs to the farm and for marketing their products.

The cost of inputs, as exemplified by plowing, also appears to be less for Group II (Table 8).

COST TO PLOW ONE MANZANA, BY GROUP

GROUP	I	II	III
COST TO PLOW (IN ¢)	107.4	106.6	113.5

Table 8

ACCESSIBILITY OF FARM MACHINERY, BY GROUP

GROUP	I	II	III
% RESPONDING THAT MACHINERY ALWAYS AVAILABLE	52.9	40.0	61.0

Table 9

The only area where they appear to be at a relative disadvantage is their inability to get machinery when they need it (Table 9). This, however, does not appear to be a real constraint since much of the actual work is done by hand. When asked if laborers were available to weed, Group II's relative position improved (Table 10).

AVAILABILITY OF LABORERS, BY GROUP

GROUP	I	II	III
% RESPONDING THAT LABORERS ALWAYS AVAILABLE	64.2	75.0	80.0

Table 10

Results of decisions which are implemented today are felt in the future. If a person is deeply concerned and dependent upon contemporary circumstances and events, he will heavily discount possible future benefits in favor of perceived certainty in the present. When asked if they agreed with the statement: "...an intelligent person should think about the present without worrying about what can happen tomorrow," the lowest percentage was in Group II (Table 11). Their concern with the future suggests that

PERCENTAGE, BY GROUP, PRESENT ORIENTATION

GROUP	I	II	III
% AGREEMENT OF PRESENT ORIENTATION	76.4	53.0	69.0

Table 11

they discount long-run returns at a lower rate than would the other two groups. In other words, their perception of I_2 on Figure 3 (p. 14) would lie further to the right; possibly far enough to induce adoption.

It appears that when one senses a control over his destiny success is considered as highly probable and failure is discounted. When asked if luck or hard work was necessary to better themselves (Table 12), Group II relied the least on luck for success. This feeling of an ability to control their destiny is further noted

DEPENDENCE ON LUCK, BY GROUP

GROUP	I	II	III
% FEELING LUCK NECESSARY FOR SUCCESS	47.0	26.6	30.7

Table 12

when they were asked if it was better to just start working, or make plans first (Table 13). The effect of assigning a high pro-

IMPORTANCE OF PLANNING, BY GROUP*

GROUP	I	II	III
RATIO OF: JUST START WORKING / MAKE PLANS FIRST	.45	.2	.09

*SINCE "making plans first" is in the denominator, the ratio shows an inverse relationship, i.e., the smaller number the more important is planning to the group.

bability to success would be to shift $\bar{I}$ to the right in Figure 3 (p. 14). If it were to shift far enough, $U(\bar{I})$ would become greater than $U(I_0)$, implying that adoption would take place.

Institutional Confidence

In the main body of this paper it was stated that the relationship between the farmer and the institution has an important function in the adoption process. Extended contact with an institution or experience with many institutions should reduce some of the uncertainty facing the farmer. Furthermore, if his experiences have been favorable the probabilities that he attaches to the institution's claim of success will not (or only to a small degree) be discounted.

In order to examine the relationship between institutional reliability and adoption the following question was considered. "How have your experiences been with _____?"3/ The number of institutions with which each farmer had had contact was tabulated and then averaged over each group (Table 14). The results pointed

INSTITUTIONAL CONTACT, BY GROUP

GROUP	I	II	III
AVERAGE NUMBER OF CONTACTS (POSSIBLE 5)	1.8	2.3	2.7

Table 14

3/ The names of five institutions working in that area were successively inserted into the question. These were: 1) Ministry of Agriculture & Livestock; 2) National Production Council; 3) National Bank of Costa Rica; 4) The Bank of Costa Rica; and 5) The Anglo-Costarican Bank.

out that the larger farmers have had more experience with more of the institutions charged with development in that zone. It may be the case that these institutions regard the larger farmers as their most important clients.

To further examine this relationship the answers to the above questions were coded: 1 - for good experiences; 2 - for so-so experiences; and 3 - for bad experiences. The coded answers were summed and averaged by group. This gave a group by group measure of discontentment with the development institution (Table 15) in the zone. Group I, the poorest farmers, not only had the fewest

AVERAGE DISCONTENTMENT WITH INSTITUTIONS, BY GROUP

GROUP	I	II	III
DISCONTENT	1.82	1.11	1.27

Table 15

contacts, but when they did their experience was less favorable. Group II, while having less contact with the institutions than Group III, nevertheless found its experiences more satisfying.

To combine these two indicators into one measure of institutional reliability the coefficient of discontent for each group was subtracted from "3." Since "3" represents strong discontent, subtracting the coefficient from "3" will give a measure of group satisfaction. This new coefficient was multiplied, in turn, by the average number of institutional contacts (Table 14).

INSTITUTIONAL RELIABILITY

GROUP	I	II	III
RELIABILITY	2.0	4.3	4.6

Table 16

The results are shown in Table 16. The higher numbers indicate greater reliability in the institutions, since they are a function of satisfaction and experience. Groups II and III have had favorable contacts with more institutions than Group I, thus they would be less likely to discount claims and promises than Group I. This is represented in Figure 5 (p. 22) by Groups II and III accepting the institution's claimed outcome of I' and eventually adopting the innovation. Group I on the other hand, discounts the claimed outcome to I'' and rejects the innovation.

Results

An analysis of the data from the Small Farm Survey suggests that within this apparently homogenous category, there exist heterogenous sub-groups. Using total farm size to identify these sub-groups, it was found that the cost and availability of inputs were different for each grouping. It was also noted that the groups differed as to how they valued future returns as well as to how they perceived probable sources. Finally, it was seen that farmer confidence in the institutions increased going from the poorest to the richest group.

When Groups I and II were compared, their differences reinforced the theoretical argument put forth in this paper. However, when Group III was included the relationship was not as exact. This may be due to a number of factors, the most probable being the decision to consider Group III as a whole, rather than to further break it down into sub-groups. Another possible source of

AVERAGE AGE OF RESPONDENTS, BY GROUP

GROUP	I	II	III
AVERAGE AGE	39.8	41.5	51.2

Table 14

variance might lie in the age differences. The older average age of the respondents in Group III would explain their relatively high present orientation, and suggest greater risk aversion. Finally, it might also be the case that institutional borrowing after ten years has become part of their input package, and this decision, under normal conditions, is not subject to reconsideration.

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