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Risk, Uncertainty, and the Subsistence Farmer: Technological Innovation and Resistance to Change in the Context of Survival

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In general, farmers who are limited to traditional agricultural factors are more secure in what they know about the factors they use than farmers who are adopting and learning how to use new factors of production. The new types of risk and uncertainty about the yield inherent in factors embodying an advance in knowledge are of real concern to farmers. They could be of critical importance to farmers who are producing so little that there is barely enough production for survival. But since traditional agriculture is not introducing new factors, new elements of risk and uncertainty do not appear; they arise only when the transformation gets under way [Schultz 1964:31].

THE DYNAMICS OF MICRO-DEVELOPMENT: A PROLOGUE

THE TRANSFORMATION of village-level economies is essentially the transformation of peasant farmers. Few peasant farmers in the world are in a state of pure subsistence where they buy and sell nothing outside of their farms. However, the linkages which exist in a majority of cases are more heavily concentrated at a village economy level than with the wider economy outside of the village. Contact with the wider economy does exist in most cases, but its relative importance contrasted with the interface market contacts at the village level is less. Thus, these village-level economies operate much as self-contained, self-sufficient economic enclaves with communal goals, institutions and processes designed far more for the preservation of human life than for development. Since in its earliest phases, sedentary agriculture is a productive process whose product may be eaten by the producer, there is inevitably a strong attachment by the peasant farmer to the goals, institutions, and processes associated with the economy, society, and polity of the village.

Despite the almost infinite variety of village-level institutions and processes to be found around the world, they partake of three common characteristics of importance for change: (a) they have historically proven to be successful, i.e., the members have survived; (b) they are relatively static, at least the general pace of change is below that which is considered desirable today; and (c) attempts at change are frequently resisted both because these institutions and processes have proven dependable and because the various elements constitute something akin to an ecologic unity in the human realm.

Yet the very essence of development at this micro level is an increase in the linkages of the village and the peasant with the wider world. Linkage is the path of modernization and dynamism whether through a sudden export boom or through the increased availability of non-farm produced inputs like chemical fertilizer. As these linkages increase, the range of forces beyond the control of the peasant farmer and the village increase as well. Increased dependence upon the outside world without the corresponding development of countervailing power foci which can be

manipulated by the peasantry is often at the root of rural political unrest. Moreover, not all o: increased linkages with the outside world necessarily contribute to sustained growth.

The current conventional wisdom about agricultural development to which most econor would subscribe is:

1. Agricultural development is a function of a large number of complex interrel factors—natural, physical, psychological, economic, social, cultural and political (Millikan Hapgood 1967).

2. Certain factors which significantly affect development are largely exogenous and not sub to short-run manipulation. For example, the size, composition, distribution and rate of growtl population has a major effect upon agricultural development at all levels.

3. The factors which can be manipulated so as to produce a more dynamic agriculture fall i two groups:

(a) Those which rely upon exploiting existing unrealized opportunities and the elmination existing economic inefficiencies without major changes in such areas as available technolo existing infrastructure, levels of demand, current agricultural prices or motivations and spirit people. Programs in this area seek to improve the decision-making of farmers, their allocation resources, improvement in marketing information, and the elimination of monopsony monopoly gains. While such efforts can contribute to change in agriculture, they rarely lead t more dynamic or sustained rapid rate of growth.

(b) Those which involve significant changes in one or several of the factors held constant un the first. This category of factors perhaps contains elements where a dramatic change has numerous occasions in the past led to dynamic or discontinuous jumps. These variables are t most likely to provide the greatest short-run gains or "shock" to a static system. As a rule most these change slowly, but the surprising feature of recent history is the frequency with which maj and rapid breakthroughs have occurred in a number of these factors.

All "developers" love to play the game of "key factors." Let me also play the game and list t seven which I currently consider to be the major forces capable of contributing to *dynamic* chan in agriculture.[1]

1. Changes in Technology. When technically feasible and economically feasible, the diffusi and adoption of new technology can often lead to dramatic changes and development agriculture. These changes can be reflected in increases in yields and reductions in per unit co which in turn lead to increases in quantities sold, and returns to the farmers. Dramatic ar significant changes in the technology available to farmers can also have an important derivati effect upon their perceptions of opportunity and motivation to change in general.

2. Changes in Infrastructure.[2] Major changes in infrastructure, particularly irrigation, road storage, and other marketing facilities, can often be of signal importance in effecting dynam changes in the agricultural sector served. For example, irrigation, which gives greater assurance c water and improves its availability and distribution, or which permits the most effective utilizatio of other farm inputs, can often lead to major sustained change in agriculture. The two-wa facilitation provided by roads and improved transport can occasionally alter the inpu cost/product price ratios leading to significant increases in output and yield. Similarly, their role i heightening marketing efficiency and access to markets in general need not be belabored.

3. Changes in Demand. Major shifts in the levels of effective demand for agricultural outpu have usually led to dramatic responses, even by the most traditional agriculture. At times, thes dynamic changes have been caused by strong shifts in domestic demand due to increases in pe capita income. (There is an important unexplored question here regarding the role of populatio on which views differ sharply.) At other times, these shifts have been the result of changes on th export side.

4. Changes in "Prices" or the Terms of Trade. Major changes in the terms of trade betwee agriculture and non-agriculture leading to an increase in the real value of agricultural product can sometimes serve as a major stimulus to a dramatic take-off in agriculture. This phenomenon is more likely to occur when the increases in income lead to patterns of capital formation and investment in agriculture which strengthen its productive capacity.

5. Changes in Motivation of People. The motivations of people, not merely farmers but also those serving farmers and the elite, are often central to development. Attitude toward change and the spirit with which individuals approach development can be affected by a number of variables producing a heightened sense of dedication, willingness to make changes, altered patterns of behavior, and changes in the objective functions (goals) of people. Causes of such changes in the past have been wars, achievement of independence, and major revolutions which altered the balance of political power.

6. Changes in Institutions.[3] Changing the "rules of the economic game" and "access to the game" can often have a major impact upon the pace of development. Despite the mixed evidence, land reform is usually cited as an institutional change which can effect dynamism in agriculture. Similarly cited examples are an increase in the political franchise of rural people and the development of local financial institutions adequate for external linkage to national capital markets. Such changes significantly alter the institutional context within which the economic processes are carried out.

7. Changes in Knowledge of the Development Process. A final variable which we tend to ignore is the change in knowledge of the development process. We are apt to forget how much our knowledge of the process of development has grown in the past twenty years. While we do not know all the answers, there is little doubt that there has been substantial progress in what is known about heightening the pace of development. This increase in knowledge is itself perhaps one of the most significant inputs for accomplishing change in agriculture as it is brought to bear on policies, plans, and programs for agricultural change.

The present paper is hopefully a contribution in the seventh area while focusing on problems associated with the first.

THE SUBSISTENCE FARMER

A growing literature is emerging regarding the subsistence and peasant farmer.[4] While conceptions and definitions differ in detail, the population embraced by most definitions of a "subsistence farmer" tends to result in basically the same group. The core group comprised by these definitions[5] is a farmer who (a) consumes most of what he produces and/or sells very little of his product in the cash market; (b) buys very few items to use in farming and for consumption; (c) uses very little, if any, non-family labor; (d) employs a level of technology which is usually described as traditional or primitive and which changes slowly if at all; (e) suffers a level of living which while not close to the biological minimum is still judged as meager by most standards; and (f) operates within a decision-making context where the issue of family survival predominates and therefore where his primary goal of production is for home consumption rather than for the market.

The close interrelationship between minimal subsistence levels of living and the prevalence of high degrees of risk and uncertainty which are so frequently associated with subsistence and peasant farmers is a neglected but highly important influence upon the economic behavior of such farmers.[6] The influence of risk and uncertainty upon economic behavior in agriculture has received occasional attention,[7] but the predominant focus has been upon the commercial agriculture of modern, industrial nations[8] rather than the subsistence agriculture of the developing world. The notable exceptions are the pioneering essays by Porter (1959), Dutia (1961), Gould (1963), Myren (1964) and the collection of articles in the 1964 *Indian Journal of Agricultural Economics.*[9]

The present article will attempt to review the available literature and to explore the conceptual and analytical issues involved in the relationship between subsistence levels of production, plus the usually associated subsistence levels of living, and the influence of risk and uncertainty factors upon the adoption of new technology. In brief, the article is an attempt to provide a more rigorous framework for analysing the frequent statement about farmers in developing areas that "they are so close to minimal human survival that they resist innovation and change." No attempt will be made to develop another new model of peasant economic behavior[10] or to present still another "Game Theoretic" framework of "man against Nature."[11] Rather the object of the essay is to

explore more fully the inherent meaning, elements, and dimensions of "subsistence" and su as viewed by peasant farmers.

Even though the remainder of the article will concentrate upon economic factors, it shou emphasized at the outset that economic factors are neither predominant nor exclusive in adoption or rejection of new technologies—new seeds, new practices, new crop combinations, inputs. Among farmers in the developing world economic factors *are* important in the proce the diffusion of new innovations, but non-economic factors are often equally critical. None of analysis which follows should be interpreted therefore as a denial of the significance of s factors. Indeed, the paper may help to redress what has been a past imbalance of overempl upon non-economic explanations for resistance to change.

THE RESPONSIVENESS OF SUBSISTENCE FARMERS

The earliest characterizations of subsistence or traditional farmers described them technologically backward, with deficient entrepreneurial ability, and with limited aspirations. T influence of limited aspirations is best summarized in the colonial stereotype of the "lazy nativ who refuse to work for an income beyond what they require for their subsistence requireme (Black 1953:536). Economists labeled such behavior the "backward bending supply curve labor." Although they pointed out the existence of backward bending labor supply curves in *bo* developed and undeveloped economies, the sophisticated theorizing about leisure income effe and the utility of money was not terribly appealing when applied to primitive and only partia monetized societies. Other social scientists who were more culturally sensitive and empathet viewed any behavior which superficially appeared to constitute a denial of greater economic ga as merely instances where non-economic variables dominated and swamped economic facto favorable to economic maximization.

Interestingly, these early views of limited or negative peasant responses to econom opportunity were held by many individuals who were witnesses to or participated in instances massive "response" by subsistence and peasant farmers to improved economic opportunities. Th colonial period in many of today's developing nations offers considerable evidence of economi responsiveness.[12] In most instances, the economic opportunity was the dynamic development o new markets in the colonizing (or imperial) home country for the beverages, food, and industri raw materials which could be produced in the colony. Some but not all of the rapid dynami response in these cases can be explained by the coercion of colonialists, or by the development o infrastructure facilities by the colonial power or by a crop's promotion by "chartered companies' and cartel-type agency houses.

More recently, the idea of an economically inert peasantry has been subjected to seriou challenge. First, there are those economists led by Professor Jones (1960) and Professor T. W. Schultz (1964), who find ample evidence that subsistence farmers *are* economic men who do maximize in the utilization of their available economic resources *given* the available technology. Such farmers may be operating at low absolute levels of production but they are nevertheless optimizing at the ceiling of the available technological possibilities. This group argues that what is fundamentally lacking is improved technology. The obvious solution under such circumstances is to give first priority to the development of new technology to alter the production possibilities available to the subsistence farmer. Sizable investment in new technology, if successful, would enable the subsistence farmer to apply his economizing skills at a higher absolute level of production.

Second, a large number of economists have been conducting rigorous empirical research to determine whether or not such farmers respond to economic incentives. Despite the varieties of empirical and analytical measures used and crops involved, the overwhelming evidence indicates that subsistence and semi-subsistence farmers do in fact respond to economic incentives (Krishna 1965, 1967; PWFS 1967:Ch. 9; Behrman 1969; Bateman 1969). They increase the production of those crops whose relative economic returns have improved and decrease those which have become disadvantageous. Some of the observable response has come as a result of greater intensification in the use of available resources without any significant alteration in the existing technology; others

have come through the adoption of new techniques and practices. Whether or not the agricultural sector as a whole is responsive to economic incentives is still open to debate and being investigated by a number of researchers.

Despite all the new evidence on the economic responsiveness of subsistence farmers, there is equally ample evidence, usually in semi-anecdotal or case study form, where farmers have seemingly not responded to an "obvious" economic opportunity (Borton 1967). Explanations of such cases vary. Some analyses rely upon non-economic explanations—the indigenous culture militated against the new practice; there were serious religious prohibitions which would prevent the adoption of a new technology; higher production would disrupt the fabric of the traditional society. Others find that upon closer examination the economic advantage turned out to be illusory—the landlord secured all the gain; the moneylender skimmed off the cream; the government guaranteed price was not in fact paid; the cost structure made the new innovation unprofitable.

All of these explanations have varying degrees of merit in certain instances. Yet the current pressures of burgeoning population on world food supplies have thrown into relief the need for more rapid economic responsiveness and the more rapid adoption of available new technology if the race is to be won. Improved understanding of the resistances to adopt or to respond is becoming critical. One set of explanatory variables which deserves more rigorous study is the influence of risk and uncertainty juxtaposed against the subsistence levels of living and subsistence production of such farmers.

SOURCES OF RESISTANCE TO TECHNOLOGICAL CHANGE

New technology is becoming the current vogue on which rest the hopes of agricultural development to meet the challenge of the food/population race (Stakman et al. 1967; Moseman 1967; Rockefeller 1968). Investment in agricultural research on the physical and biological aspects of the plants and animals which provide sustenance for the three-fourths of the world engaged in agriculture has become the new magic key. The massive concentration of research talent and funds in crash programs to produce rapid payoffs with dramatic breakthroughs in agricultural technology have become the newest entrant in the parade of solutions for underdeveloped agriculture.

For the economist and the social scientist, however, new technology is neither an automatic panacea nor always an automatic source of dramatic growth (Johnson 1968). For the economist, true technological change is that which involves an increase in productive efficiency such that a larger output is obtained with the same input bundle of land, labor, capital. Since differences persist as to the appropriate definition of "innovation" among social scientists (Ruttan 1959; Rogers 1962), I shall use throughout the term "technological change." The term will be used in the same sense advocated by Ruttan (1959:606) "to designate changes in the coefficients of a function relating inputs to outputs resulting from the practical application of innovations in technology and in economic organization." Thus "technological change" will embrace those changes in the previous relationship between outputs and inputs in a productive process such that a greater output is now possible from the same bundle of inputs from any of the following sources singly or in combination: (a) a change in the quality of the input, i.e., the new technology is embedded in the input such as a higher yielding variety of seed, or (b) a change in the economic organization or use of the inputs, such as a recombination of the same inputs in a fashion which results in higher output per unit of input, i.e., new knowledge on the timing of fertilizer application without any change in amount or (c) a new practice of farm operation, such as the time of planting or depth of planting, which would result in higher yields without any other change in the quantity and quality of inputs.

Naturally, this "pure" or neutral notion of technological change which appeals to the empirical economist interested in analytical rigor rarely approximates the situation in the real world. This is especially true where dramatic new factor inputs are available within which the new technology is embedded but which cannot be obtained without altering the other inputs and their mix.

TABLE 1. HYPOTHETICAL EXAMPLE OF SUBJECTIVE PERCEPTION AND OBJECTIVE REALIT REGARDING RICE YIELDS FROM STANDPOINT OF DIFFERENT PERCEIVERS

	(Metric Tons per Hectare) (Probabilities in Percent)	
	Farmer	Outsider
SUBJECTIVE PERCEPTIONS	3.2 tons (80%)	5.4 tons (95%)
OBJECTIVE REALITY	4.8 tons (90%)	5.1 tons (90%)

There is little question that dramatic technological breakthroughs have been occurring fc selected agricultural crops which in turn have been adopted by farmers and have had a dramari impact upon agricultural productivity (Griliches 1958; Barletta 1967; Evenson 1967). But ther are also numerous cases where a technical breakthrough has occurred on the research statioı without adoption or significant impact on aggregate agricultural productivity having taken plac (Castillo 1968). A marvelous case study of where breakthroughs were made on two crops by the same organization with differing results is the Rockefeller Foundation program in corn and in wheat in Mexico (Myren 1969). Similar evidence abounds in the literature and case studies of development where a technological breakthrough was resisted by the farmers leading to what some have called a "technological gap." This "technological gap" is seen by the governmental change agents as a potential source of higher productivity; but despite efforts to close this "gap," the farmers have not adopted the new technology.

In such typical situations, resistances to adoption tend to fall into three broad categories: (1) those which revolve around the *farmers* themselves; (2) those which are associated with the *technology* or innovation itself; (3) those which are *external* both to the farmer and the innovation but which are situational, environmental, or institutional (Hsieh and Ruttan 1967).

In examining each category, two careful distinctions must be kept in mind:

First, a careful distinction must be made among the *different viewers* of the phenomena in question, especially between the farmer and the change agent.

Second, an equally important distinction is best seen as the difference between "*subjective perception*" and "*objective reality*."

The "objective reality" may be that the new technology will increase yields by 25% with a 95% probability, but the "subjective perception" of the new technology may be a 15% increase in yield with only a 75% probability. It should be emphasized that there is no reason why the "objective reality" could not in fact be *higher* than the "subjective perception" in various cases.

When these two distinctions are joined, one can readily see the divergences which can take place when a new innovation is being promoted and is being considered. A hypothetical example is given in Table 1 on rice yields per hectare with a new technology. Let us assume that the outsider in this case is the extension agent. His subjective perception of the new technology is a yield per hectare of 5.4 metric tons and a probability of 95% but the objective reality is 5.1 with a probability of 90%. The same phenomenon when viewed by the farmer may have a different set of values subjectively and objectively. The reason for the difference between the two objective realities could be that the objective reality as seen by the change agent is for all farmers within his area whereas the farmer's is for his specific farm. If the change agent knew the farmer's farm as well as the farmer does, the objective realities would be the same. Since the change agent does not, their respective realities diverge. In this case as well there is no a priori reason why the farmer's objective reality should be lower; it could be higher. Similarly, subjective perceptions can diverge for a number of reasons. For example, a farmer who is an early adopter and who has never previously tried the innovation and who has only seen it on a nearby farm demonstration usually tends to add a significant discount factor to any estimates of yield derived from his immediate observable experience (see below).

Finally, it must be emphasized that there are important interactions between one or more of the three categories.[13] For example, lack of awareness among the farmers regarding the true merits of the proposed innovation (category 1) may be due to improper methods of extension education (category 3). Similarly, if the extension agents do not truly understand the new managerial practices called for with a new variety (category 3), they may fail to provide the farmers with the required managerial skills (category 1).

The relevant variables within each of the three categories, like so many development problems, constitute a wide amalgam. Many of these variables are traditionally considered to fall within the purview of a particular discipline or branch of science and range from the social psychological variable of farmer attitudes and motivations to the agronomic variable of soil texture and porosity. No attempt will be made at integrating all the relevant variables, even limiting the range to the social sciences, because there is no generally accepted social science model of change and development. Nor will there be an attempt at an exhaustive listing of all the relevant variables. However, it may be possible and useful to list the six sets of variables which experience reveals as the most frequent reasons for the failure of farmers to adopt a new recommended technology. Again, these are not mutually exclusive in any given situation, but are a useful check list for any change agent.

The Farmer[14]

1. *Not Known or Understood.* The new technology may not be known by the farmers. Despite the efforts of the change agents, the bulk of the farmers may not have heard of the new technology.[15] The media and agents are just not reaching the farmers to make them "aware" of the new technology—a step which is unavoidably the first requirement in the normal progression toward ultimate adoption (Byrnes 1966). Or the farmers may be in touch with the agents, but the methods of extension employed may be unsuitable or ineffective.

2. *Not Within Farmers' Managerial Competence.* The farmers may have heard about the new recommended technology, but the comprehension of what it can do or the effective utilization of the new technology may require new knowledge and skills on the part of the farmers which they do not have. Unless the farmers are provided with these new improved managerial skills, they will not adopt the recommendations.

3. *Not Socially, Culturally or Psychologically Acceptable.* A great deal is made in the development literature of those cases where a new practice or a new technique has not been adopted because it would upset too severely the established patterns of social or economic or political organization. A new planting or harvesting practice which is labor saving might eliminate the traditional labor service of the wives or relatives. The "gleaning" rights of wives in the harvest fields is a frequent example. The importance of such forces in the subsistence and semi-subsistence context is indeed considerable as has been amply established by the work of anthropologists.

The Innovation

4. *Not Technically Viable or Adequately Adapted.*[16] Very often the new recommended technology has not in fact been locally adapted or tested under conditions which more closely approximate those faced by the farmer. The government experiment station may have a location, soils, and climate quite different from that of the farmers. Subsistence farmers are sufficiently shrewd to discern whether the new variety or new practice seems to have had enough adaptive research and local testing to meet their unique local needs. If the new technology has not had adequate adaptation or if a small trial run on a "demonstration plot" reveals that it is not in fact technically viable, community resistance to the new technology quickly develops.

5. *Not Economically Feasible.* Probably the biggest single cause of resistance to change is the unprofitability of the new technology as seen by the farmer. In many cases the new technology may be *physically* better but not necessarily *economically* better. A new technology usually requires an alteration in the input mix—either in its utilization or more important in its composition. Equally often, the new technology requires the purchase of additional inputs to

achieve the higher productivity—and these inputs have a cost. And when the farmer compares t expected output plus its associated income with the additional costs of the input, the balan sheet employing the new technology is found wanting.

The "Externalities"

6. *Not Available.* Often the new technology is embedded in a physical item such as see pesticide, fertilizer, or equipment. But unless the new item is readily available to the farmer i quantities and at the time when he needs it, knowledge of its potential contribution to hi agricultural production will not result in its adoption. Adequate provision of the new inputs mus be assured and most often these come in a combination or "package" so that not one but all mus be readily available before adoption will take place. A fertilizer-responsive new seed might b available, but it will be of limited value to the farmer unless fertilizer is also available.

These six are neither mutually exclusive nor the sole determinants of resistance; they als frequently interact with each other in a particular situation.

The history of past technical assistance is littered with instances of "new technology" which i labelled as both "new" and (automatically?) "better" has in fact proven to be unsuited and no technically viable. Some of these failures have been due to the improper recognition of th non-transferability of temperate zone technologies to tropical and sub-tropical zones. Less crud but equally common have been those failures due to an inadequate recognition of the need fo adaptive research which will take a new technology and reshape it to fit specific growing conditions. Still other instances of failure can be attributed to "slippage" which occurs due to such factors as poor seed multiplication or improperly trained extension agents. While such considerations are of the greatest importance, in the analysis which follows they will be ignored because for our purposes they do not really constitute a "new technology" at the farm gate. The following analysis, therefore, will assume that the technology being discussed is in fact "new" in the sense that it is technically viable, technically superior (at least in so far as higher average yields), and adequately adapted and locally tested for use by individual farmers. Even under these circumstances there remains a sizeable question regarding the economic feasibility of the new technology.

One frequent objection to the introduction of economic feasibility in the case of subsistence farming is that product is not monetized or only partially monetized. But the relevance of profitability still is involved even where the introduction of new technology is not the issue.[17] For example, Robinson Crusoe did not try to reach the absolute maximum of total physical production on his garden plot because his labor had a value in other "economic" pursuits. This simple fact is too frequently forgotten by those change agents who criticize the farmer who does not try to achieve maximum total physical productivity on each square inch of his acreage. If the farmer is asked to plant a new variety which is responsive to fertilizer, the seed perhaps and certainly the fertilizer will cost him money. If the new variety requires improved water control, then he must invest in better distributaries or water controls or even improved levelling of his fields—which again involves a cost. If he is asked to plant a shorter term variety, he must weigh the increase in output (and hopefully income), against the added cost of its harvest during a period when additional drying and/or storage costs may be incurred. Moreover, the costs incurred by the low-income farmer are often greater than the nominal price of the new input. If he is short of capital and must borrow, the interest charges must be added and such charges may be considerable where money lenders or merchants exercise monopoly or monopsony powers (Wharton 1962; Long 1968a).

Thus, the peasant farmer must compare the increased returns (greater output times expected prices) against the increased costs (new required inputs times known costs) before he is able to make a decision on the economic feasibility of the proposed technology. If he feels that the new technology is not economically viable for him, he will not adopt it. Any careful review of the myriad case studies of resistance to change will unquestionably show that the economic viability of the proposed change has been a most important determinant of adoption or of resistance.

Among the economic forces influencing technological adoption are the variables risk and uncertainty which have been a somewhat neglected dimension of resistance to change among subsistence farmers. The primary focus of the remainder of the paper will be on the influence of risk and uncertainty and their dynamic interaction with two sets of economic variables: (a) the absolute levels of farm living as they relate to social standards for the minimal levels of subsistence and the average levels of farm productivity; (b) the subjective (farmer's) expected variance in output associated with a proposed new technological introduction compared with the historically determined variance in output utilizing traditional practices.

RISK AND UNCERTAINTY IN THE CONTEXT OF SUBSISTENCE AGRICULTURE

The Causes of Risk and the Sources of Uncertainty

The basic conceptual distinction between "risk" and "uncertainty" owes its origins to Frank H. Knight (1921) where he set forth the notion that "measurable uncertainty" to which one can assign numerical probabilities should be called "risk" and true "uncertainty" is where numerical probabilities can not be applied. Knight's pioneering efforts have spawned a sustained debate on the further refinements of the distinction, on the determinateness of the probabilities, on questions of ambiguity, and on similar issues.

Rather than attempt to cope with the very extensive issues and arguments in the literature on the validity of the distinction between the two concepts, I would like to refine the precise content of these two concepts for the subsistence farmer as decision-maker.[18] Thus far, the arguments in the literature have revolved around a distinction which focuses upon the ignorance of the decision-maker as to the statistical frequencies of events related to his decision. The assumption in most cases of "uncertainty" is that the decision-maker cannot assign a priori calculations to determine the probabilities especially when anticipated events are considered to be unique or of the "once-and-for-all" variety.

The two basic distinctions which are relevant for the decision-making framework of the subsistence farmer are (a) those future events to which he can assign probabilities based upon past experience or personal knowledge, and (b) those future events to which he cannot assign probabilities or where the probabilities offered are not those derived from his personal experience and which are based upon external knowledge provided by others. Both can be said to have probabilities, but the distinction being drawn is based upon the source of the estimates. In the former case it is the farmer himself; in the latter, it is usually an outside agent.

The peasant farmer who uses traditional techniques has a set of customary probabilities regarding the outcomes of his farming decisions which are based upon his own past experience and that of his forebears. The farming practices, the technologies applied to his production, have significant and predictable consequences not only for any given year but on the average among several years. The proof of his skill in determining these probabilities is the simple fact of his family's survival generation after generation.

Even the most illiterate peasant farmer has a knowledge of the probabilities which attach to his current, traditional practices. His current practices have both a risk and an uncertainty dimension which relate to three major sources of year to year variability in output:

First the farmer faces *yield variability*. The acreage which he plants to a given crop may be the concrete summation of his estimate of a variety of forces, but the actual yield obtained is not solely dependent upon acreage but a whole host of intervening factors between planting and harvest—some subject to the control of the farmer; others, in the laps of the Gods. Actual field or barn yields obtained are a function of a wide range of variables—sunshine, humidity, rainfall, and even their incidence and timing during the cropping season; pests such as birds, rats, worms; blights, fungi, and viruses; and even the unpredictable acts of God and man such as wars, insurrections, and revolts. All these forces converge to determine the actual yield which will be obtained in any given crop year. (Post-harvest losses while stored, processed or transported could also be included if the loss is borne by the farmer.)[19]

Second, there is *cost variability*. Despite the predominance of subsistence and semi-subsistence type agriculture which heavily involves "subsistence production," there are still inputs required for production which are sometimes purchased. These items range from minor farm tools and fertilizer to oxen rental and hired labor. Whether or not actual "cash" is employed in the payment process is inconsequential. The critical issue is the variability in the incidence of such costs. The typical farm decision-maker faces a number of such expenses which tend to fall into two categories: those which are endogenous in the sense that they are subject to his decision-making control and those which are exogenous in the sense that their costing and incidence are outside his control. In both cases, however, predictable and unpredictable probabilities are involved, i.e., risk and uncertainty. Family labor is fundamentally an endogenous variable whose utilization and remuneration is subject to the control of the farm decision-maker. But, its utilization is affected by illness and even the availability of off-farm employment. There are a number of exogenous factors which are subject to year to year variability and for which the farm operator must predict specific values in advance of or during the crop season. The costs of farm product processing such as milling, and off farm storage and transport to market are equally exogenous from the standpoint of the farmer. Knowing what these costs were in previous and the most immediate years helps him in formulating the probabilities to assign to numerical values for the current year, but they are inherently external to his personal control. The same applies to production and consumption credit, both before the crop is planted, during the crop season and after harvest (Long 1968b).

Third, there is a *product price variability*. Choice of crop and crop combinations as well as intended levels of output are based upon price expectations—relative prices expected to obtain at harvest or time of product sale.[20] The actual price forthcoming is of course outside the control of the farmer (in the usual textbook sense of an infinitely elastic demand curve or price being given). The divergence between expected prices when crop choice and planting decisions are made and actual prices may be considerable, both positively and negatively. Free market forces, monopsony situations, government controls, price floors or guarantees, and similar factors may come into play. These calculations are further complicated by seasonal, cyclical, trend or random forces.

The critical element is that these three variabilities combine in any given crop period to affect the net return to the farm family. The extent to which the farmer can reduce unintended fluctuations in each category is quite limited, but every effort is made to reduce those subject to his control. Historical knowledge of the past variabilities in each does exist and he takes these into account whether it is distrust of assured government prices or a locust cycle.

Under the usual conditions of traditional or subsistence agriculture, the farmer's knowledge of the average yields and their probability distribution is greatest. When a new technology or crop is introduced, it affects the first two variabilities most significantly.

The risk and uncertainties associated with these variabilities are the normal decision-making and operational environment for agriculture generally. In the case of subsistence and semi-subsistence agriculture, however, these variabilities combine with low levels of income (output) or "subsistence" levels and standards of living to produce a much stronger "survival" element in decision-making.

> Even though the average annual yield of the new factor is substantially higher than that of the old factor which it replaces, it may vary much more from year to year because of weather, insects, and other pests.[21] Moreover, the true yield variability of the new factors from these sources will not be known, while that of the old factor is well known from experience over many decades. Thus there would be inherent in the prospective yield of the new factors these new elements of risk and uncertainty. They must be taken into account, too, in determining profitability, especially so since farmers in a poor community are less able, in terms of reserves and experience, to cope with such additional risk and uncertainty than are farmers in high income countries [Schultz 1964:167].

Compared with commercial agriculture, subsistence agriculture has a stronger "risk aversion" and "security preference." This fact results in economic choices and institutions to reduce risk and to increase security ranging from the selection of drought resistant varieties (Myren 1964:97) to reliance upon the extended family (Wolf 1966:67) or upon the village (Georgescu-Roegen 1969) to provide food/job insurance.

In the present instance we would like to explore further the exact nature of this interaction between risk and subsistence living so characteristic of peasant farming.

The Role of Subsistence Standards and Levels of Living

A previous article (Wharton 1963b) sought to clarify the ambiguous use of the term "subsistence" by distinguishing between "subsistence production" and "subsistence levels of living." Though both "subsistence production" and "subsistence living" frequently coincide, they are not necessarily synonymous. A model was presented to explain how minimum standards of subsistence living are determined at any point in time and how they are changed through time. The model was intended as an aid in describing and analysing the influence of minimum standards of subsistence living at the micro-economic and individual farm family level. The model may be briefly summarized.

In any given socio-economic unit, there exists some social consensus as to the standard minimum bundle of goods required per person per specified period of time. The bundle is above the level needed for physical survival, i.e., no marked deterioration causing death prior to the normal life span in that particular social economic unit. The absolute size and composition of such a bundle is bounded on its lower side by the physiological requirements for human survival, but the values above the lower limit are controlled by economic-socio-cultural factors. There are subjective notions of minimum subsistence standards of living and the content of a minimum standard varies between social aggregates depending upon historical and current economic-cultural factors. The higher the previous economic levels of well-being historically, the higher will be the current subsistence living standards. Such a variable can be viewed as operating in some lagged fashion, i.e., the current minimum standard is some function of previous economic levels weighted in some fashion. Thus, a short-run drop in current economic levels need not result in a lowering of the minimum standard; such a change would come only as the result of prolonged and sustained drops in economic levels.

The minimum subsistence standard[22] of living per person within any particular social aggregation of individuals such as a village, can be described as a function of three types of variables: (1) physiological and nutritional; (2) economic, especially current and previous levels of economic well-being; and (3) socio-cultural in an historical and cross-cultural context.[23]

For an individual in a specified homogeneous social aggregate and for any specified time period the relevant variables may be symbolically defined as follows:

S_{as} = achievement standard of living

L = actual level of living

S_{ms} = minimum subsistence standard of living

P_m = minimum physiological requirements (below which death)

The minimum subsistence standard of living, S_{ms}, cannot be less than P_m, the physiological minimum below which death takes place, but note that S_{ms} could still be low enough to cause nutritional deficiencies and result in reduced capacity for physical exertion.[24]

Any particular social aggregate, farm family or village, has an S_{ms}, a general consensus as to what is a minimum subsistence standard of living per person. However, the S_{ms} need not be the same for all social aggregates within the same nation or geographic area and need not be the same for a given socio-economic unit through time.

It is important to note that S_{ms} is different from the traditional notions of a standard of living as a goal which the individual always strives to reach. The subsistence standard is a something which the individual strives *to avoid* or not drop below. Thus, if we call the traditional standard the "achievement standard of living," S_{as}, and the actual level of living per person, L, then L is usually equal to or above S_{ms}, the minimum subsistence standard, but always below S_{as}, the achievement standard of living. S_{ms} in turn is above the physiological minimum, P_m. The relationships can be summarized as:

$$S_{as} > L \geq S_{ms} \geq P_m$$

A central argument to much of what follows regarding risk is that the significant operative variable with important behavioral implications is not P_m, but the relationship of L to the S_{ms}, the minimum subsistence living standard.

Many economists when talking about subsistence levels of living are usually thinking of P_m, the minimum physiological requirements, which are in fact fairly constant from person to person, once account has been taken of age, sex, physical activity, and climate.[25]

Attention has also tended to focus upon the relationship between actual levels and the achievement standard. In our view, however, the relationship between actual levels and the minimum subsistence living standard may be even more important in the case of subsistence and semi-subsistence production. This is particularly true where the actual level of living is close to the minimum subsistence standard and where in turn both are very close to the physiological minimum.

Behaviorally, the individual strives to attain S_{as}, the achievement standard of living, and to stay above S_{ms}, the minimum subsistence standard of living. The closer that the actual level of living, L, of an individual comes to his minimum subsistence standard, S_{ms}, the more strongly it affects his behavior to avoid reaching it. Whenever an individual in the social group is at or below the S_{ms} for that group, he is aware of it and will strive to get and stay above it.[26]

The same comments are valid for a "family group" as well as for an individual. Since S_{ms} is minimum subsistence standard of living *per person*, we can easily convert this into a minimum subsistence standard of living *per family* by taking account of numbers in the family or operative social unit where the number of persons in the family (the "common pot" definition) is counted using some standardized adult unit basis. Thus family "numbers" would not be strictly the number of family members, but a composite variable which takes account of such compositional factors as age and sex. Thus, when dealing with a typical peasant or smallholder type of agriculturist who predominates throughout the underdeveloped world, he and his family will have a family minimum subsistence standard of living as well as family achievement standard, and a family actual level of living.

Similarly, each of the standards, S_{ms} and S_{as}, and level of living, L, can be given a valuation per family per specified time period such as the total dollar expenditures per year per family for an actual level of living.

What is particularly relevant for the present discussion are those farmers (a) most of whose actual level of income comes out of their farm production (i.e., those who are near the pure subsistence production end of the spectrum) and (b) where their actual level of living and minimum subsistence standard are close to the physiological minimum. For such farmers, the forces of risk and uncertainty have a special influence.

Types of Subsistence Farms

Let us assume an area of subsistence farming (a) where the total product is food, (b) where there are no cash production costs (such as taxes) and no purchased inputs (land and labor are the major factors of production, and minor equipment or farm capital structures constitute an embodiment of farm family labor), and (c) where the annual level of living for the farm families is entirely out of farm production. For simplicity, valuation of production and levels of living (consumption) can be made in units of a food staple such as kilograms of rice. Under these assumptions, L which is a consumption variable and which is traditionally a function of income becomes virtually a direct function of output. Actually, total output less production costs equals farm consumption plus farm production sales plus savings. But we will ignore production costs and savings: (a) We have assumed above that cash production costs are zero. (b) There is some evidence of a constancy in the saving rate among peasants which "is consistent with the fact that the marginal utility of consumption does not decrease very fast in the relevant range of income per capita" (Lau 1967:25). The more critical question concerns the relationship between consumption and sales. There are some who argue that peasant farmers have a target farm family demand out of farm production and that sales are a residual. Others (Mathur and Ezekiel 1961) believe that such

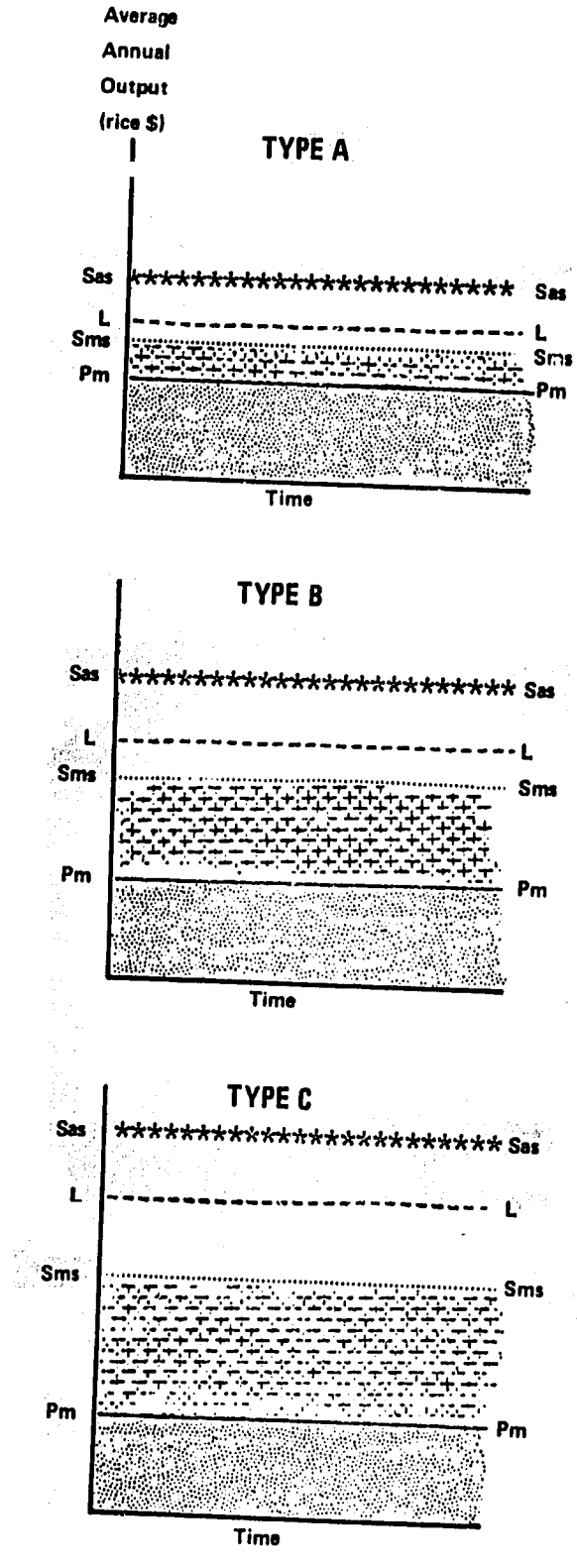
Average
Annual
Output
(rice $)
TYPE A
Sas
L
Sms
Pm
Time
TYPE B
Sas
L
Sms
Pm
Time
TYPE C
Sas
L
Sms
Pm
Time

Figure 1.

farmers have a target cash requirement (for non-farm produced consumption goods, ceremonial or religious expenditures, taxes, and interest payments) which must be met thereby making consumption the residual.

Regardless of one's position on these contrasting views, there is little doubt that the larger the fraction of total farm product consumed by the farm family, the closer the direct functional relationship between output and consumption or level of living.

This characteristic is of critical importance because it determines the degree to which decisions regarding output, consumption, savings, and investments are interrelated. In a pure subsistence peasant household, output and consumption are virtually equivalent so that "income" and consumption are jointly dependent. Several models of peasant economic behavior relying upon this interrelatedness of production and consumption have been developed (Sen 1966; Nakajima 1969; Krishna 1969). Each follows fairly similar assumptions regarding utility, production, etc., and demonstrates that even in pure subsistence cases, farm output is a function of the traditional production variables and level of technology employed. Hence, the actual annual level of living experienced by a peasant family through time is a function of the absolute level and quality of resources employed in production and the technology employed. The closeness of this level of living to the physiological minimum and to the minimum subsistence standard is consequently closely related to the farmer's resource and technological endowment.

Under such circumstances, it would be possible to discern three types of farmers or three different situations depicting the interrelationships through time of levels of living, achievement and subsistence standards, and physiological minima (Figure 1). (The farmers are all assumed to have the same numbers/sex/age composition so that the minimum, P_m, is identical.) In situation A the typical low-income subsistence case, the range among all four variables is quite narrow. S_{ms} is close to P_m and L is close to S_{ms}. In this case, physical survival considerations are paramount. In situation B, the intermediate case, S_{ms} is substantially higher than P_m. This may be due to a variety of reasons such as larger or higher quality resources or better technology which provides an average annual level of living considerably greater than the P_m. In this case, notions of a minimum subsistence standard are dominant. In situation C, the high-income, commercial case, S_{ms} is higher than P_m, but now an increased difference between S_{ms} and L is evident. In this case, the achievement standard and the actual level of living assume their normal roles as determinants of behavior. It must be emphasized that in the real world, these three types are not discrete and that there is in fact a continuum. However, the three cases highlight those situations where the dominant behavioral considerations are different.

Our analysis is particularly concerned with farmers in type A and B situations, especially the former.

The Dynamic Interaction of Risk, Uncertainty and Subsistence Upon Technological Innovation

Technological change occurs only when the innovation is actually adopted by the farm operators. Since the decision-making or choice context of the farmer is at the root of the adoption process, any new or suggested technological introduction or innovation must be viewed from the standpoint of the farmers.

Any new technology or practice has associated with it certain expected probabilities regarding yields per acre and their associated income figures. These estimates are primarily derived from the results of experiment stations and varietal trials.[27] The variations in yield observed on the various trials on the experiment station plots and in farm demonstrations need not be, and usually are not, those which will be experienced by the particular farmer who is contemplating the new adoption or innovation. Associated with each experiment station and field or farm trial are certain expected variations in results, i.e., each practice or each new variety has a certain predictable variation in actual yield even under the conditions of the experiment station or field trial. But this expected variance in yield is not the same as the variance (expected or derived) from the application of these techniques or new inputs on a particular farm. Moreover, change agents who are promoting the

new technology usually sell it in terms of the maximum experiment station yield or the average yields obtained by the station. "This new variety gave twice the yield which you (the farmer) are now getting."

The typical subsistence or peasant farmer has his own subjective rate of discount for the introduction of a new technology on his farm. Despite its testing by the central, regional or local experiment station, or even on neighboring farmers' fields, the subsistence farmer has learned from bitter, historical experience to be wary of "technological gifts," which *as he sees them* have been insufficiently adapted and evaluated for his particular situation. The subsistence farmer has learned that any new recommended technological introduction has associated with it a different expected variance on his fields—a variance which may be wider than that on the fields of the research station. Under these circumstances the determining fact is the comparison between the expected variance of the new technology and the known variance of the traditional technology. Whenever a change agent approaches a farmer with a new technology the farmer examines the proposed changes within the framework of known versus unknown expectations. He compares the expected probabilities from continuing as he has done in the past with its given degrees of risk and uncertainty, on the one hand, with the expected probabilities from the new technology on the other. Critically important in the latter is the fact that the probabilities are those provided externally to his experience—the extension agent tells the farmer that the average yield from the new practices will be "x," but the farmer does not necessarily know that this is so from his own directly observable experience. In the Knight sense, what may appear to the extension agent as a risk in the calculable probability sense, based upon experiment station data, becomes for the peasant farmer an "uncertainty." Utilizing our earlier terminology, both the subjective perceptions and objective realities of the farmer and the extension agent diverge. A critical element thus becomes the "degrees of belief" or the firmness of reliance which the farmer can place upon the estimated probabilities associated with any particular decision for a new course of action.

Let us assume that we are dealing with a type A subsistence farm family which consumes 80% or more of their annual average farm production. Let us further oversimplify by assuming that this 80% of production equals the total bundle of consumption goods[28] which constitutes the level of living for the family. In good years and in bad the amount of production reserved out of the staple food production on the family farm remains fairly constant. Thus, in good years he sells a higher fraction of his total production and in poor years, less. The critical factor is that at all times he seeks to preserve or guarantee the minimal subsistence living of his family out of production; consequently, the absolute minimal production reserved for family consumption remains fairly constant.[29] This level of consumption is related to my concept of a minimum subsistence standard of living described earlier. Given a particular S_{ms}, a typical peasant family will strive to reach the communal or societal achievement standard, S_{as}, and most important it will struggle to avoid the S_{ms} which is the minimum subsistence standard. Even though the P_m is considerably lower than most individuals realize, the crucial fact is that each farm family resists having a level of living which is significantly below the S_{ms}. In other words, it is not so much whether the ingredients are nutritionally adequate for human physical survival—viz. roots and berries—as it is the accepted community and social standards for "survival."

The next element in the farmer's decision-making package is the expected variances in yield and hence in output and income associated with existing practices. The agricultural technology currently employed by most subsistence and peasant farmers is traditional in the sense that it has been handed down from one generation to the next. The farmer has a basis for determining the expected variance in yield and in income derived from the experience of his father, grandfather, and great grandfather. Hence, he knows what to expect in good, average, and poor years. On the whole, these expected variances are not only real, they are the product of centuries of experimentation by trial and error.[30]

The final ingredient in the picture is the expected variances which attach to the new technology and practices. The variances in yield are those which are derived from the experiment station. From the farmer's viewpoint there is no guarantee that such variances will apply to his particular, unique combination of ecological and human factors. Thus, even though the *average* expected

yield may be considerably higher than his average yields with current varieties and practices, the *variance* in expected yields with the alternative technologies as viewed subjectively by the individual farmer are far more important in determining the adoption of the new seed, practice or factor input.

The dominant failure in much of developmental assistance aimed at technological innovation has been the lack of understanding about the relationship between the (a) expected variance in yields using current varieties and practices; (b) the expected variance of yields using new varieties and practices; and (c) relationship of these to the absolute levels of living and the minimum subsistence standards of the "clientele."

Despite the considerably larger expected *average* yields from new seeds and practices, the critical issue for the peasant farmer is the expected variance in output under the new regime compared with the old. If the expected variance in yield per acre[31] shows a possibility of an output *below* his S_{ms}, then the farmer will resist the introduction and adoption of the new change. He will not wish to gamble or to risk the life of his family. He will prefer to stay with the present practice with which he is familiar and which is known to him than shifting to that which is new untried, and untested and which therefore has a wider variance.

The situation may be summarized graphically for a typical farmer (Figure 2). His customary average annual output, O_T, has associated with it a standard deviation $\pm\sigma_T$ where the one negative standard deviation is still above his family's S_{ms}. In time period t, he faces the possibility of adopting a new variety. Associated with this new variety are a series of *subjective* expectations—average output, O_N, which is higher than the traditional variety, but a variance, $\sigma_N 2$, which is considerably larger than when cultivating the traditional. If the farmer's subjective expected negative standard deviation is below the S_{ms}, the farmer will resist the adoption. It should be emphasized that $\sigma_N 2$ may well be wider than the real variance in actual practice as determined on the experiment station or in trials on farmers' fields. This will be especially true during the early stages of adoption when there is a lesser degree of certainty regarding expected yields as seen by the potentially innovative farmer.[32] The larger the number of farmers in his neighborhood who have tried the new variety the closer the farmer's subjective variance will be to the real variance. Even in those cases where the two variances converge but the negative standard deviation lies below the particular S_{ms} of the farmer, he is likely to resist. These are the cases usually referred to as a technological innovation which offers limited gains—insufficient to encourage adoption.

If, on the other hand, the one negative deviation lies above the S_{ms} with an average output higher than the past output with traditional varieties, the farmer is far more likely to adopt despite the wider variance which may attach to the new practice (Figure 3). Under these circumstances, adoption is likely to proceed rapidly. As we shall see later, when the negative standard deviation is above the traditional average output, then adoption will proceed very rapidly indeed. (These are the cases which are usually referred to as situations of dramatic output increase possibilities.)

It should be emphasized that not all farms in a particular region will be characterized by either Figure 2 or 3. Often in a given community, a potential innovation will be juxtaposed against farms of both types. This fact explains why certain innovations experience differential diffusion. Larger farms and those farmers with larger assets are much more likely to be similar to Figure 3 or to have levels of output even utilizing traditional varieties which are considerably above their S_{ms}.

The recent experience with the new rice varieties from the International Rice Research Institute is perhaps indicative. The rapidity with which the new varieties (especially IR8 and IR5) have been spreading in Asia refutes the stereotype of the non-economic peasant. The Philippines has traditionally been a rice importer—some 230,000 tons annually from 1961 to 1967. The very rapid adoption of the new high yielding varieties first introduced in 1966 has already made the Philippines self-sufficient in rice for the first time in recent history.

Some micro-economic data on the adoption is interesting from two standpoints (Table 2).

First, the variance in yields per hectare (σ^2) associated with the newer varieties is considerably larger than with the traditional varieties (6.86 to 2.76 metric tons per hectare in the dry season and 3.61 to 1.74 in the wet season). Hence the new varieties result in a wider variation in possible results—both positive and negative. If the average yields for the new and old varieties had been

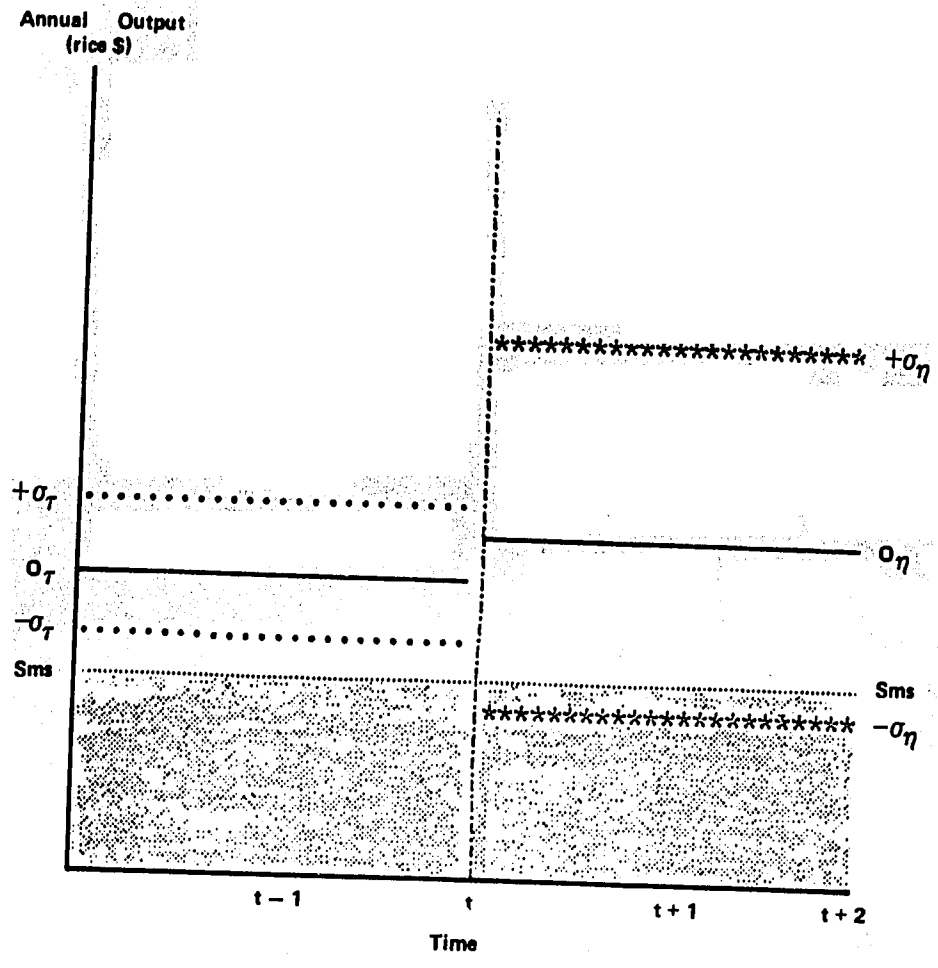

Figure 2.

TABLE 2. AVERAGE YIELDS OF IR8 AND LOCAL RICE VARIETIES IN THE PHILIPPINES, DRY AND WET SEASONS 1966-67[33]

	(Metric Tons per Hectare)		
	$-\sigma x$	$\bar{X}$	$+\sigma x$
Dry Season			
IR8	3.24	5.86	8.48
Binato	1.51	3.17	4.83
Wet Season			
IR8	2.59	4.49	6.39
Local	1.00	2.32	3.64

fairly similar, then the average farmer would probably have resisted adoption because even though the average output with the new practice would offer a bigger prize, the negative prospects would have him end up below the traditional yields.

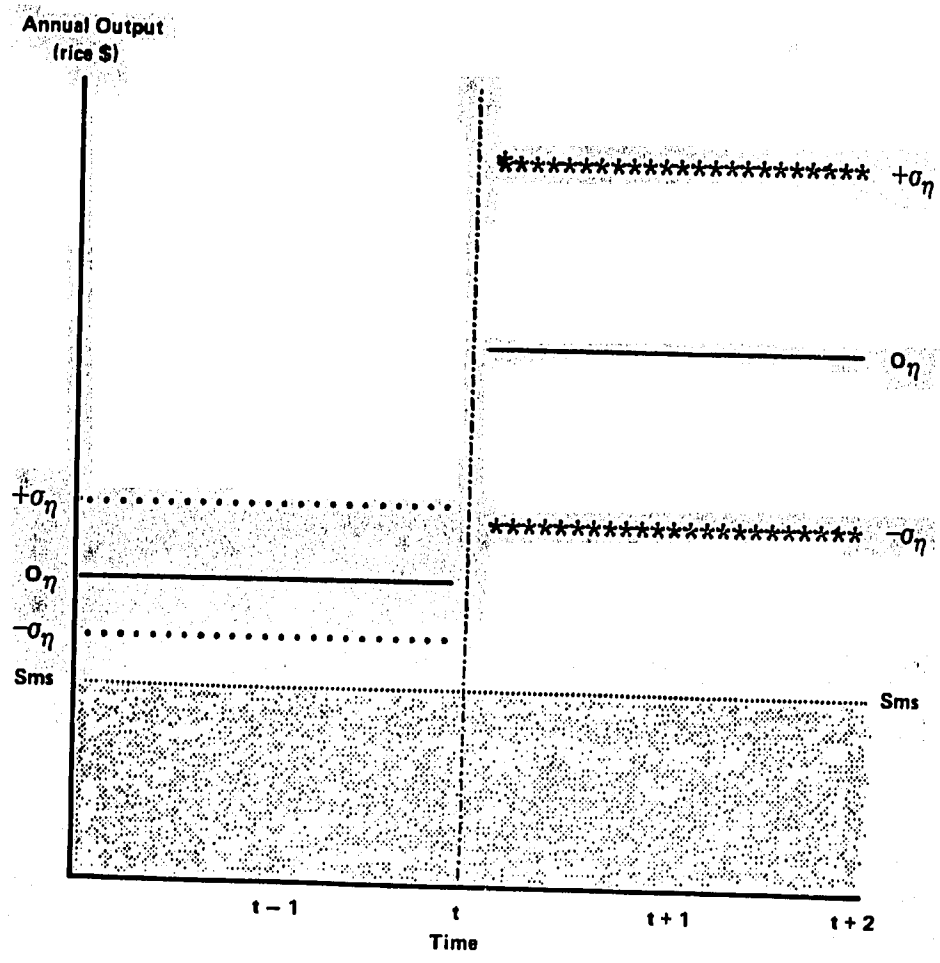

Figure 3.

Second, what is especially significant in the present case is not merely that the average yields with the new varieties are higher, but that the negative standard deviation for the new varieties is *higher* than the average yields of the old traditional variety: 3.24 metric tons per hectare for IR8 compared with 3.17 with the traditional varieties, and in the wet season 2.59 compared with 2.32. Thus, the farmer who adopts the new varieties faces a situation (even allowing for a negative standard deviation) in which he would experience a higher yield than the average with the traditional varieties.

This example helps to explain the startling phenomenon currently taking place with the so-called "Green Revolution"—the rapid adoption of the new high yielding varieties of wheat and rice (Rockefeller 1968; Brown 1968).

A second body of interesting evidence comes from the recent research of Behrman (1966, 1969) on rice supply elasticities in Thailand. His study was based on data from 50 Changwads (provinces) in Central and Northeastern Thailand, 1940-63. In estimating the short-run elasticity of area planted to rice for the period 1940 to 1963, Behrman employed three independent measures as surrogates for risk aversion: (a) the standard deviation in price over the three preceding years; (b) the standard deviation in yields over three preceding years, and (c) population residing in agricultural households. The choice of the first two was based upon the strong presumption that they were suitable proxies for the variances of the subjective probability distributions. For both distributions, an asymptotically significant response was obtained in less than half of the provinces. For both distributions, the mean value of the implied elasticities with

respect to the standard deviation is substantially smaller than the mean value of the implied elasticities with respect to the expected value of the same subjective probability distribution. The third variable was seen as a reflection of possible peasant behavior in planting enough area in rice to assure sufficient food for the household. For approximately 70% of the provinces the estimated response to this variable was asymptotically significant.[34] The fact that the population/food survival variable stood the test better than price or yield variability alone lends further support to our emphasis on the critical role of minimal subsistence in the economic decision-making of subsistence peasant farmers.

Three points of caution as we move from the restrictive theoretical setting to the greater complexity of the real world. First, it would be a serious mistake in most instances to look upon the absolute levels and variances in yield for a *single crop* as the appropriate measure. To the extent that there is some degree of diversification in production, the obviously relevant measures should refer to the farm as a whole.

Second, there is the obvious importance of introducing costs associated with any new technology. For example, from studies conducted at IRRI (1967), they estimate that the total cost of production per hectare using traditional methods and varieties is about US $200. On the average less than 10% of this is a cash outlay. When IR8 is grown, greater use of fertilizer and chemicals is required so that costs per hectare double, and almost all the increase is in cash. Thus, *cash* expenditures rise from US $20 to US $220.[35] Fortunately, in this case *yield* increases threefold, leading to a net return four times greater than traditional varieties and methods yield. Although most diffusion studies do take such costs into consideration, the risk cost associated with minimal subsistence, S_{ms}, is not.

Third, the quantification of an S_{ms} is admittedly difficult. A number of possible proxies might be suggested to reflect this minimal standard: (a) for any sample we might use the percentage of total farm product consumed in the home to construct a community index and then select an arbitrary cut-off point (e.g., the lower decile or quartile) as the S_{ms} for the community; (b) we might estimate the fraction of total consumption (food plus non-food) out of farm production to construct an index and then select an arbitrary cut-off as with (a) above; or (c) we might merely use the estimated measures of farm family consumption (farm plus non-farm produced) and then use the negative one standard deviation for the sample as the approximate locus of the S_{ms}.[36] Each measure would be highly arbitrary but would at least render the S_{ms} operational.

The above model as developed represents an extreme case of a subsistence agricultural producer. Nevertheless, the model is instructive in helping to explain differential response or adoption in the real world.

Given a close historical relationship between average annual food output and a farm family's S_{ms}, the degree of risk aversion or resistance to an innovation will be *reinforced* by the following five factors:

1. the less the extent of food/non-food crop diversification on the farm;
2. the less the availability of other food sources;[37]
3. the less the availability of alternative economic opportunities for the employment of farm resources,[38] especially family labor;
4. the closer to unity is the ratio of the value of annual family S_{ms} to the farmers' net worth (asset/debt structure);[39]
5. the scarcer the capital available to the farmer (including relevant interest charges) (Dutia 1961; Long 1968a, 1968b).

Several recent models have been proposed and tested empirically which attempt to describe situations where the concentration in decision-making is upon the risk taken rather than on the possible gains.[40] Three efforts are especially noteworthy. Boussard and Petit (1966) have expanded and applied Shackle's (1949, 1961) "focus of loss" approach. Using this approach the assumption is made that "farmers want to maximize the 'normal,' or mean, value of their incomes under the constraint that the focus of loss . . . is at least equal to the permissible loss, that is, to the difference between the mean income and the minimum income" (p. 873). Perhaps the most interesting and potentially useful of all is the recent formulation by Karl Borch (1968).

CONCLUSION

The six dominant characteristics of subsistence farmers with which this essay began delineate a class of farmers who are influenced by special factors or factors whose weights are different. These factors in turn lead to different types of economic behavior and correspondingly different patterns of development.

One factor of importance in the context of subsistence agriculture is risk because of its close interrelationship with survival. The interrelationship is especially evident with technological innovation. Although new technology constitutes a major dynamic force for the modernization of peasant agriculture, its introduction among subsistence farmers often encounters resistance. *Profit maximization may not be as important in a subsistence or barter economy as the maximization of security and survival.*

Previous measures of risk, which rely upon such variables as the cost of the new input, or its net returns, and the year to year variability in these (and similar measures such as yield), production costs and product price, are poor surrogates when applied to subsistence agriculture. A better approach would be to observe the interaction between two sets of variables: (a) the absolute levels of farm family living as they relate to social standards for the minimal levels of subsistence, and the average levels of farm productivity and income; and (b) the farmer's subjective expected variance in output associated with the proposed new technological introduction compared with the historically determined variance in output utilizing traditional practices. What must be taken into consideration is the *variability* in the expected results with the new technology, not merely measured against costs as usually defined, but against the minimum subsistence standard and the variability experienced with current technology. What is needed is a risk aversion or security preference measure which takes this interrelationship into account.

Some Puzzles and Paradoxes Explained

Our analysis may help to explain a number of puzzles and paradoxes which are commonly encountered with technological innovation in the developing world.

1. *Differential Adoption Within Same Community.* In many agricultural areas, one can find farmers who have adopted a new innovation coexisting with neighboring farmers who have failed to adopt even though the latter see the new technology every day and are aware of it. "Demonstration effects" and "neighbor effects" seem to have no impact upon adoption by the remaining farmers.

2. *Food Staple versus Non-Food Staple Variations.* A common experience is a differential resistance to technological adoption between staple food crops and non-staple food crops. Technological innovation tends to move more rapidly among farmers specializing with non-food staples (especially commercial crops) than is true with food staples, even where there is no significant relative price discrimination.

3. *The "Dual Farmer."* One frequently encounters farmers who grow both a food staple and a non-food staple on their farms. Yet they are willing to innovate or to employ a new technology with a commercial crop but persist in utilizing traditional practices with the food staple.

4. *New Crops versus Old Crops.* Another common observation has been that the introduction of new crops requiring new technology into the farming regime of a peasant seems to be easier than changing the technology of a traditional, well-established crop.

In each of the four cases, a good deal of the variation in adoption can be attributed to the relationship between subsistence standards of living, and the expected variance in output of the food staple under the new technology. In the first case, for example, the non-adopters are most frequently those farmers who are less commercial (both in sale of products and purchase of inputs) and whose resources relative to their S_{ms} are extremely close. Where the proposed innovation and its associated variance exceeds the S_{ms}, such as was shown to be the case with the new rice varieties in the Philippines, then adoption proves to be swift.

Some Program and Policy Implications

There are some obvious policy and program implications of the above analysis. If risk and uncertainty are as important in the context of subsistence as indicated, then certain steps are required to assure a greater rapidity and extent of adoption of new technology.

First, information on the output or yield *variance* of any new technology is as important as its average output performance. Any determination of the economic feasibility of a new practice or technique should pay equal, if not more, attention to the variance in yields, especially the lower deviations as they relate to minimum subsistence standards of living of potential innovating farmers.

Second. in developing new technologies, agricultural research organizations should recognize the importance which subsistence farmers attach to the variances associated with any possible innovation. Plant breeders, for example, should pay greater attention to those specific characteristics which may help to reduce negative deviation and offer greater dependability.[4 1]

Third, where only a narrow range covers the minimum subsistence standards, levels of living, and physiological minima (Type A situation in Figure 1), programs designed to diffuse new technology need to pay much greater attention to methods for "risk insurance" (Marglin 1965), or assuring the peasant who innovates that failure (i.e., an output falling below his minimum subsistence standard) will not result in a major penalty, viz. loss of life or loss of property or indebtedness. Existing social structures and institutions (viz. extended family) which already provide some degree of "risk insurance" should be recognized as such and wherever possible treated as complementary to any new insurance system.

Fourth, methods of technological introduction and trial in a peasant community should recognize that in the early stages the typical farmer in the community attaches a subjective variance to the expected yield of the new technology which is considerably wider than the true variance. Extension and information measures should concentrate just as much on reducing this subjective variance in the minds of potential innovators as on spreading knowledge about the average or maximum yields. Assurance as to the *dependability* of the practice or technology may be more important to the peasant farmer than its impressive maximum or average output possibilities.

Peasantry throughout the world constitute the largest fraction of mankind and their pattern of life is one of the oldest in human history. The peasant, through his inherited institutions and his traditionally determined socio-economic behavior, has developed a strategy to win the basic struggle for survival. He will not relinquish this strategy easily.

One of the most dramatic and dynamic forces inducing change in traditional societies is new technology. Subsistence economies and agrarian societies provide a security which has the force of historical certainty in the survival of the peasantry and their community. Under these circumstances, attempts at change, especially those which come into direct conflict with the fundamental goals of security and survival, must take into account the degree of risk and uncertainty associated with the change.

Our attempt has been to give greater precision and understanding to one major variable which inhibits innovation among a very large number of farmers in the developing world. Risk is not the only factor which retards development; there are others, but its elimination or reduction should prove a major stimulus for technological innovation and the modernization of subsistence agriculture.

NOTES

[1] There are numerous lists of "key" factors ranging from Mosher's (1966) five essentials and five accelerators to the Adelman and Morris (1968) empirical finding on the overwhelming importance of improvement in effectiveness of financial institutions, improvement in physical overhead capital, degree of modernization in outlook, and leadership commitment to development. For a fuller presentation of their analysis see Adelman and Morris (1967).

[2] The term "infrastructure" is used here in the broader sense set out in my earlier work (Wharton 1967).

[3]The conceptual delineation of "institutions" and their role in development is a needed though difficult task in which my colleague, Dr. Weisblat, is engaged.

[4]For a more detailed rigorous exposition on the universe embraced by the terms "subsistence" and "peasant" see Wharton (1969:Ch.2). The use of the term "subsistence" is sometimes preferred in view of the pejorative connotations of "peasant" in some societies, but as used, the term includes more than the "pure" subsistence farmer.

Concern for peasantry is of long-standing among anthropologists. (For recent summaries see Wolf [1966], Nash [1966], and Firth [1969].) Economists have only recently focused their research upon peasant farmers (Wharton 1969:Ch. 14).

[5]The critical factor is that these definitions do not seek to delineate a "subsistence" sector in the traditional dual model sense, but to identify a subset of farmers who share common characteristics which lead to common patterns of economic behavior. However, some economists (Miracle 1968) feel that the term "subsistence" however defined is too broad to cover the diversity and heterogeneity embraced by the term and may be misleading by focusing undue attention on merely one characteristic. While I readily applaud any stricture against univariate classification which masks the fundamental heterogeneity of any universe, one should be equally prepared to eschew the counsel of no classification at all. Subsistence agriculture and subsistence farmers are rarely classified on the basis of a single characteristic (Beal et al. 1967), despite sewing and stuffing of straw men by objectors. The critical issues are whether or not the classification system is appropriate for the analytical purpose at hand and whether or not the classification is appropriately determined. "Women" is an appropriate category for certain analyses; "blondes," "brunettes," and "redheads" for another. Sex may or may not be relevant; similarly, hair color. The classification can not be divorced from the purpose of analytical usage. Any caution to the contrary is a disservice to the cause of scientific inquiry.

[6]The problem of risk was frequently raised at the recent International Seminar on Change in Agriculture at the University of Reading, England (September 3-14, 1968). Five of the eight specialists' syndicates mentioned risk as an important variable significantly affecting agricultural change. The conference studied over 50 case studies of agricultural development around the world. See also Wharton (1963a, 1963b).

[7]Cochrane (1955), Hildreth (1957), Johnson et al. (1961), Reutlinger (1963), Tedford (1964), and Merrill (1965).

[8]This has been particularly true of empirical work: USA (Dillon and Heady 1961; Johnson 1962; Davidson and Mighell 1963); Australia (Officer et al. 1967; Officer and Halter 1968; Anderson and Dillon 1968); France (Boussard and Petit 1967); and Sweden (Wolpert 1964).

[9]In preparing this paper, I regret that I have been as yet unable to obtain two theses which have come to my attention by Sipra Das Gupta and Judith Heyer dealing with certain aspects of risk in the context of Indian and East African agriculture respectively.

[10]The models to which I am most partial are Nakajima's (1969) and Krishna's (1969) since both try to take account of subsistence levels of living and minimal standards.

[11]The game theoretic framework has been frequently used for decision-making under conditions of uncertainty. For an excellent summary see Krishna and Desai (1964).

[12]Andrus 1948; Furnivall 1957; Hill 1963; Myint 1964; Berry 1967; McHale 1967; Pfanner 1969.

[13]These interactions are often further complicated by disciplinary boxes. For example, Edel (1967) reports two interesting cases of Jamaican fishermen where an income maximization and risk minimization model explains certain patterns of economic behavior (viz. choice between shallows and deep-water fishing) but which does not become generally valid in explaining other actions (viz. acceptance or rejection of spear-fishing and cooperatives) until community solidarity and social structure are explicitly introduced.

[14]Those who have read my previous work will be surprised at the absence of peasant motivations and attitudes within this rubric. The more that I have delved into the subject the more I am becoming convinced that the problem in this particular area is not so much determining the attitudes and motivations which are disincentive to change or dysfunctional for development as determining the precise ordering or weights of relevant elements in the preference functions of peasants in a particular situation so as to prepare the proper strategy—especially selection of targets, their timing and sequences. Motivational problems are much more critical in the case of political elites, planners and those serving farmers.

[15]Myren (1964) believes that the critical factor to offset risk aversion among peasant farmers is "adequate information about the new inputs which are proposed. This includes potential adaptability to the farmer's own land and climate and a vast number of details about the techniques to use with the new crop or practice."

[16]A great deal is made in the literature regarding the divisibility and complexity of an innovation and the extent to which it requires major restructuring of the productive process. For convenience, these attributes will be subsumed under "technically viable."

[17] This area is one where I suspect I may differ with my colleagues in economic anthropology (Dalton 1961). While there may be differences as to the goals of production and distribution in such situations, I would argue that the means employed *within the firm* still follow economizing rules. For further treatment of the issue in a cross-disciplinary context see Wharton (1969:Ch. 14).

[18] Despite the extensive debate on the point, I will assume throughout this paper that peasant farmers behave rationally (Wise and Yotopoulos 1968) and are utility maximizers. The critical question then becomes the content of the objective function and the relative weights assigned, especially to such elements as profits (net returns) or security or social prestige

[19] Day's (1965) rigorous study of yields using U.S. data showed that field crop yields were non-normal and that the degree of skewness and kurtosis depended upon the amount of available nutrients. Similar findings for yields in developing areas have not yet been established, but their apparent significance should not be lost as one observes the necessary increases in fertilizer application required by the newer varieties. The point is not that increased fertilizer application should be avoided but that its effects upon yield distribution characteristics should be recognized.

[20] An interesting question is the extent to which the choice of crop and crop combinations may not be wholly price determined for the semi-subsistence low-income farmer who must first assure an adequate food supply for his family and who is reluctant to be dependent upon market forces. A few economists have argued that maximization in labor use and in farm family own farm inputs may be the primary goal in production in cases of subsistence agriculture (Wharton 1969:Ch. 14).

[21] Oñate (1967) has some interesting empirical evidence of increased variance to be observed with higher yielding varieties of rice compared with the traditional.

[22] "Standard" and "level" are carefully distinguished. The latter refers to the actual, existing components, whereas the former refers to the desired components.

[23] For a variety of reasons, I consider Nakajima's revision of my equation an improvement (Nakajima 1969). $S_{ms} = P_m + g(E, C)$ $g \geq 0$ where E = economic well-being variable and C = cultural variable.

[24] Such minima have a long history in the literature. For some recent examples see Mellor (1963), Fei and Ranis (1964), Miracle (1968), and Nakajima (1969). The role of such minima in determining an "agricultural surplus" has been the source of debate among anthropologists (Dalton 1960, 1963; Orans 1966).

[25] For an interesting recent critique of these standards from a nutritional standpoint see Oshima (1967).

[26] Note similarity to Chayanov's concept of "self-exploitation" (Chayanov 1966:Ch. 2).

[27] While field trials and farm demonstrations may help to reduce the subjective variance which a peasant farmer may attach to the new technology, *some* variance still remains. Thus the logic of the argument remains—each farmer must still live with his individual risk.

[28] We could use a food staple as rice as the sole product or numeraire.

[29] This statement is not quite accurate as is shown in my earlier formulation where the current minimum subsistence standard is a function of a number of variables including previous levels of income. It also oversimplifies in ignoring the obvious effects of the income elasticity of demand for farm produced food which though declining as development proceeds is still quite high for low income producers (Stevens 1965:55).

[30] An interesting related observation is the frequent finding that in areas which suffer occasional droughts the local traditional varieties are often drought resistant at the expense of not providing high yields in good years. The farmers have chosen varieties which offer an insurance against severe loss or ruin. My colleague, Arthur T. Mosher, has also pointed out another interesting example from North India: where irrigation is not available the farmers follow a practice of sowing wheat and gram or barely and gram mixed together in the same field. If the season is "good" (adequate rainfall), the wheat or barley will yield well. But if the season is unfavorable, the gram will still mature and help compensate for poor wheat or barley yield.

[31] More correctly, the lower level of the variance associated with a one or a two negative standard deviation.

[32] Besides the dearth of information on the basis of which to formulate his expectations regarding yield and its variance, the farmer recognizes that there is a greater likelihood of his performance being subject to wider error during the early stages of adoption due to unfamiliarity with the variety, its requirements, and the changed practices which may be required by the new technology in order to realize its potential.

[33] Data provided by Dr. Randolph Barker of the International Rice Research Institute.

[34] One final observation of Behrman's is that the pattern of rice supply elasticities is highly correlated with the existence of profitable alternatives (Behrman 1966:366-369).

[35] Promoters of new innovations occasionally fail to recognize the double risks associated with much of the new technology. Where the new technology requires the purchase of a "package" of associated inputs to achieve maximum returns, the peasant farmer not only subjects himself to risks in production but also in costs which are of a much higher order of magnitude than he has

previously experienced. If this action also reduces his ability to depend upon traditional forms of security (family or village) due to resentment at his innovative actions, the peasant faces a third form of risk. Any valuation and summation of all three often results in an extremely high risk factor.

Sadly, it is often hesitancy on the part of peasant farmers to incur the full costs required by the optimal "package of practices" to secure the full benefit of the new varieties which frequently leads to an actual loss. There are several cases where farmers have failed to apply fertilizer at the higher levels required with the result that traditional varieties outyield the new.

[36] My preference is for the third simply because it is easier to estimate, and distribution of average consumption figures for rural samples tend to skew to the left.

[37] Such food sources may be provided through socio-cultural institutions, viz. extended family, or ecologically, viz. proximate to easily secured wild/non-cultivated food sources such as game, roots, berries.

[38] This point can be best seen in reverse. The existence of other economic opportunities for the employment of available resources has often led to rapid innovation and expansion in production. Study of development under such situations in the past (Burma, West Africa) has led to the "vent-for-surplus" theories of development (Myint 1964; Eicher 1967). The influence of generally limited economic opportunity as it affects innovation is another neglected dimension which deserves further study.

[39] In a crude sense the farmer's net worth constitutes his ultimate reserve, either mortgagable or saleable, to cover minimal subsistence in the event of massive production failure. Peasant farmers normally have very narrow capital bases so that the margins for "risk experimentation" are also very narrow.

[40] The earlier pioneering efforts by Hildreth (1957), Porter (1959), Johnson et al. (1961), Gould (1963), Reutlinger (1963), Wolpert (1964) have a great deal to commend them to future researchers in this field.

[41] My colleague Dr. Albert H. Moseman has pointed out that much of the plant breeding work in the US during the past 25 years had paid close attention to this factor in their work for US agriculture.

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