E.D.R.P. No. 161.

PROGRAMMING CONCEPTS AND PEASANT FARM DECISIONMAKING

22 August, 1969.

by

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I. THE LANCASTRIAN CONSUMER

The novelty of Lancaster's approachto consumer choice theory - and the key to its usefulness in modified form for understanding decisionmaking in a peasant economy - lies in the assertion that the source of value or utility to the consumer is not commodities and services perse, but rather the intrinsic properties, or characteristics, of goods which make them GOOD in the perception of the consumer (we will use attributes, properties, and characteristics as synonyms). Commodities, then, are inputs of activities whose outputs are valued characteristics: the demand for commodities is a derived demand. To clarify by means of an everyday example: raw foods (commodities) are produced or intermediate inputs, combined by the use of human time inputs ('labor'), durable utensils, fuel, etc. to produce the literally consumed part of the activity MEAL (or if we want a more complete specification: chicken curry dinner by candlelight with family and two neigbors as guests). Particpants' utility derived from the activity MEAL is a function of its numerous characteristic outputs, among which we might list: taste, nutrition, and attractiveness of food; conviviality of the social setting; and pleasantness of the physical surroundings.

The examples typically used in consumer preference theory to illustrate the qualities of substitutibility (butter-margarine) and complementarity (coffee-cream) between commodities are even better as illustrations of the validity of the proposition that innate characteristics of commodities and their combinations are what render goods more or less complementary or substitutible and determine consumers' preferences.[1] Starting from this premise, we will investigate the mathematics of Lancaster's utility maximization problem.

The programming model will be introduced in terms of its components : a set of consumption activities specified in terms of their inputs and outputs; an objective function to be maximized; and constraints operating on the system.

A. CONSUMPTION ACTIVITIES

1. We postulate a set of 'm' activities, $c_1, c_2, \ldots c_m$ and a set of 'n' commodities and services, $x_1, x_2, \ldots x_n$ which are activity inputs. An activity c_i operating at unit level can be expressed as a linear combination, or vector, of input coefficients of the commodities ($a_{i1}, a_{i2}, \ldots a_{in}$). Clearly not all commodities need be inputs of every activity - we expect many zero coefficients. Activities are presumed to be infinitely divisible and freely substitutible at a constant ratio determined by commodity prices.

Activities are defined to be linear homogeneous with fixed input coefficients, so that the activity c_i operating at the level 'k' requires the vector of inputs: $(ka_{i1}, ka_{i2}, \ldots ka_{in})$. Thus for a set of activity levels $k_1, k_2, \ldots k_m$, the amount of the 'jth' commodity consumed is:

$$x_j = \sum_{i=1}^{m} a_{ij}k_i$$

In matrix notation the vector of commodities associated with a particular set of consumption activity levels is given as:

(1) $\underline{x = Ak}$ (where A is the m by n matrix of input coefficients)

We have begun with a set of linear homogeneous relations analogous to a closed input-output system and defined on goods space (GSpace).[2]

2. But we have stressed that consumer's utility is a function of the characteristics produced by activities. In order to solve the utility maximization problem, we must map the set of commodities associated with a set of activities into a vecotr of characteristics. We first assume (rather tenuously, as argued below) that a commodity or service can be completely described in terms of a set of objectively identifiable characteristics, including one or more of the set of 'r' characteristics $z_1, z_2, \ldots z_r$. By 'objective' we mean that the characteristics are intrinsic to the good and perceived identically by every consumer (as we shall see, dropping the assumption of identical perceptions leads to useful insights about peasant decisions). We further assume that characteristics are cardinally measurable, given an arbitrary unit of measure for each. Finally, we posit that a good or service posesses a linear combination of characteristics in a fixed relationship to the amount of the good.

Since consumption activities are associated with specific bundles of characteristics, we can fully describe activities in terms of their characteristics 'outputs'. Analogous to the relationship between goods and activities, the amount of the characteristic z_j produced by a set of activity levels $k_1, k_2, \ldots k_m$ is

$$z_j = \sum_{i=1}^{m} b_{ij}k_i$$

(where b_{ij} is the amount of the jth characterisitic produced by unit level operation of the ith activity). Likewise we can express the vector in characteristics space (CSpace) associated with a set of activities as:

(2) $\underline{z = Bk}$ (B is the m by r matrix of output coefficients)

B. THE CONSUMER'S OBJECTIVE FUNCTION

Consumption of characteristics gives rise to utility, thus:

(3) $U = U(z)$ (U is utility)

We postulate a complete and transitive preference ordering over all possible characteristics vectors, such that for any two vectors z^o and z', $U(z^o)$ is either greater than, equal to, or less than $((z')$; and for any three vectors z^o, z', z'', $U(z^o)$ $U(z')$ and $U(z')$ $U(z'')$ implies $U(z^o)$ $U(z'')$. Adding the premise of monotonically diminishing marginal rate of substitution between characteristics in the utility function (that is: $U'(z_i)/ U'(z_j)$ is a non-increasing function of z_i/z_j), we have the familiar convex utility function of Hicksian anaalysis, <u>but now defined on characteristics instead of commodities.</u>[3]

C. CONSTRAINTS

Having verbally acknowledged the importance of human time and stocks of durable consumers' 'producer goods' as inputs of consumption activities, Lancaster ignores the complications which they pose for specification of constraints on consumption decisions by simplifying to a linear, n-dimensional, budjet constraint defined on commodities by the inequality:

(4) $$Y \geq \sum_{j=1}^{n} p_j x_j$$ (wher Y= money income and p_j is the price of good j)

D. UTILITY MAXIMIZATION

The problem is to maximize a non-linear utility function subject to a linear budjet constraint, but with a twist. We have:

Max $U(z)$

Subject to: $$Y \geq \sum_{j=1}^{n} p_j x_j$$

and $x_1, x_2, \ldots x_n$ all ≥ 0

Given the CONSUMPTION TECHNOLOGY:

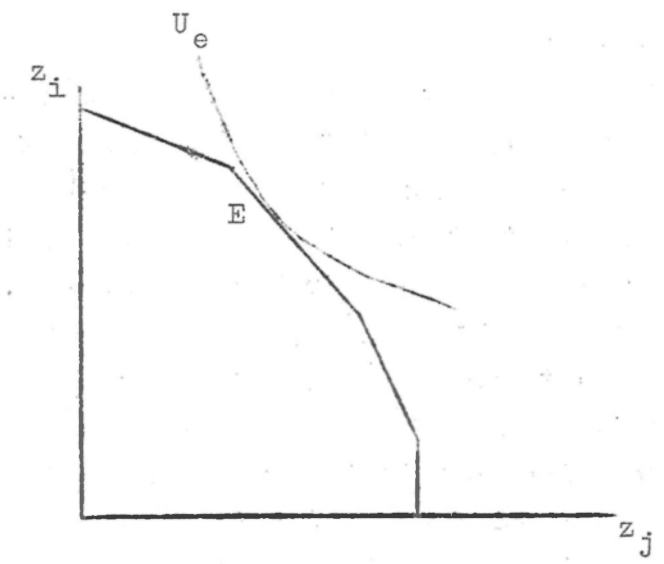
$$x = Ak$$
$$z = Bk$$

The twist, of course, is that utility is defined on characteristics while the constraint is defined on goods; therefore we must use the consumption technology to map constraints into characteristics. For the sake of simplicity of exposition, discussion is restricted to the special case $m = n = r$; that is, where the numbers of activities, commodities, and characteristics are equal.[4]

From the linear homogeneous relationship between activity levels and commodity input levels, and from the linearity of the budjet constraint, we know that the set of feasible activity vectors form a closed convex set in GSpace (concave to the origin). Since m=n=r, we can carry out a one-to-one transformation from G onto CSpace which results in a feasible set retaining the properties of closedness and convexity. (note: assuming linear independence of row and column vectors, we invert the square matrix A in $x = Ak$, to get $k = A^{-1}x$; substituting into $z = Bk$ we get $z = BA^{-1}x$. The budjet constraint, $Y \geq px$ becomes $Y \geq pAB^{-1}z$ on CSpace).

With a strictly convex utility function (see footnote 3. for programming implications of convexity vs. strict convexity) and a convex efficiency frontier bounding the feasible set of characteristics, the conditions of maximization can be shown graphically - although limited to a two dimensional slice of the n-dimensional characteristics space, as follows:

FIGURE I.



The consumer achieves maximum utility by purchasing the bundle of commodities and services which leads to tangency between his indifference surface and the efficiency frontier defined by consumption technology and the budjet constraint. It is the classic marginalizing equilibrium: the marginal rate of substitution between characteristics in preferences equals the technical marginal rate of transformation between characteristics. (note: we cannot exclude the possibility of a corner solution with one or more characteristics not consumed and non-tangency; see footnotes 3.,4.).

Change in the optimal position can occur through one or more of the following means: 1. <u>a change in the objective function</u> : alteration in the consumer's preference ordering for characteristics. 2. <u>change in constraints</u>: shift in income level or in commodity prices leading to a shift in the efficiency frontier. 3. <u>Introduction of new commodities</u>: change in the

consumption technology adding goods with new characteristics combinations (which may or may not affect the efficiency frontier depending upon the commodity's price and characteristics [illegible] coefficients - the b_{ij}'s) and possibly entirely novel characteristcs.
4. Increased efficiency in consumption activities: brought about by new information about goods/activities/characteristics combinations or through acquisition of skills (eg. cooking ability) which alter characteristics coefficients of particular activities (these kinds of change in consumption technology can be thought of as new activities).[5] Each of these change inducers, with more elaborate interpretation, is pertinant to understanding the household level decisionmaking process in peasant agriculture. We turn now from this skeletal conception of the consumer's maximization problem to the task of breathing life into the urban consumer's rural African counterpart.

II. THE PROGRAMMED PEASANT FARMER

The consumer maximization schema presented above is essentially timeless and characterized by full-information and perfect certainty (at least insofar as the failure of these conditions to apply was not discussed). The context of actual peasant decisions argues for a theory of choice stressing temporal complications, random and systematic fluctuation of variables, and subjective perceptions grounded in incomplete and possibly falseinformation. These are the most important of several extensions of the basic Lancaster paradigm which we will investigate, first by resolution into its component parts - activities, preferences, and resource limitations - and then by synthesis of parts into the complete decisionmaking framework. It should be borne in mind that our contention is not that farming systems are identical in terms of particular configurations of the variables or the technical relationships of the model. Rather, the model provides a means of considering the significance of peculiarities of a system within a more general theoretical frame of reference. For this reason, an applied approach of this kind - which does not necessarily mean an operational programming model - should be of great value for identifying the significant sources of contrast between individuals, cultures and farming systems in a more 'complete' and systematic way.[6] The objective of the exercise, in other words, is to present a way of viewing farm decisions as jointly determined by technology, resources, preferences, and perceptions.

A. ACTIVITIES

We retain the notion that the outputs of the activities in which the peasant farming unit participates are a set of valued characteristics and that commodities, including farm produce, are activity inputs. But the scope of the activity analysis must be broadened to encompass all of the activities in which the decision unit engages: we discard the assumptions that consumption activities are distinguishable from other kinds of activities and that achievement of maximum well-being consists solely of allocating a fixed amount of money income to purchasing the 'best' set of set of commodities. We must consider simultaneously all activities competing for resources available to the decisionmaking entity from its own resource stocks, through exchange mechanisms, or through modes of social action and organization of groups transcending the decision unit. Farming operations are a subset of the larger activity set; farm products, like commodities in the original model, are intermediate inputs.

Specification of consumption activities as linear, fixed coefficients in Lancaster's model led unambiguously to a convex set of feasible activity levels. We should inquire briefly into the basic features of the activity technology which, along with resource constraints and preferences, determine the pattern of choices available to decisionmakers. First we note that the farmer is likely to have some discretion in the <u>timing</u> of operations (for example, planting dates) and some opportunity for substitution among inputs within an operation (for example, manure versus commercial fertilizers). Conceptually, these possibilities are most easily handled as separate activities. Rather than proliferate endlessly the number of activities under consideration, however, it might be more useful to admit the possibility of variable input proportions. For some activities substitution among factors - over a delimited range - can produce the same set of output characteristics. As long as activities do not exhibit increasing returns to scale, then we should still expect the efficiency frontier to be convex.

Past decisions on the allocation of resources clearly affect the availability of resources for current disposition. Past land use, for example, affects the current qualitative supply of land; past decisions on the level of inputs devoted to cash cropping activities affects current money resources. For the purpose of understanding decisions taken in the present period, the effects of past decisions can be thought of as a determinant of currently disposable resources. Current decisions, however, must explicitly deal with the expected effect of resource allocation on future resource availability and not only its production of outputs for current consumption. We have, in other words, a tpye of consumption versus saving decision, but with complications as shown below. Decisionmakers' time preference is revealed both by their choice of activity levels and by the use of outputs. Generally, the outputs of activities currently undertaken may be spread over time. Decisions taken at one point in time may 'commit' the farm unit to certain resource uses in the future. The problem of time preference and decisionmaking - especially in conditions of uncertainty - is complex.

Agriculture is thought of as producing commodities which are intermediate inputs of subsequent activities, thus it may be useful to think of farming operations as one stage in a more complex activity. Just as there may be sequential interdependence between 'tasks' within an agricultural operation - for example, pre-planting application of fertilizer to a plot not only affects current and future yields, but also the level of labor inputs required for weeding and harvesting - so too, the mix and level of inputs to an agricultural sub-activity is likely to affect resource requirements and productivity in related post-harvest sub-activities. Precisely where an activity begins and ends may not be obvious.

Choice is based on perceptions not necessarily formulated from complete and valid information. Objectively specified activity technologies may diverge from the decisionmaker's subjective understanding of them. Uncertainty gives rise to risk, and uncertainty arising from limited information as well as randomness argues for a subjective probabilistic approach to understanding farmers' behavior.[7] The effects of uncertainty - about climatic conditions; the incidence of crop pestilence and disease; the prices of farm inputs and outputs and consumer goods; likely social reactions to particular kinds of behavior; and even future government policy - must be included among the characteristics of activities over which farmers have preferences. One benefit of the characteristics approach, in fact, is that risk can be resolved into the component sources and types associated with each activity. (see below under PREFERENCES for further discussion of behavior toward risk).

Human time is an [illegible] input of both farming and nonfarming activities, but unlike other resources, it also figures directly among 'outputs' in the objective function. Using the characteristics approach we can go beyond the simplistic notion of disutility of labor to discuss the characteristics of time inputs and decisionmaker's preferences for them. Relevant characteristics might include the physical demands of the activity, its social context , time of day and hours per day. (See below).

B. PREFERENCES FOR CHARACTERISTICS

The terms decisionmaking 'entity' and 'unit' have been used repeatedly as synonym for that social organization which has power to take decisions on the allocation of agricultural resources in a peasant agricultural system. The 'unit' is a fiction invoked for simplicity of conceptualization: reality belies the concept of unity. Social groupings, whether nuclear family, homestead dwelling unit, clan, or other organization are typically composed of more than one individual and/or subgroup and subject to some dispersion of preferences and decisionmaking authority both internally and visavis 'outsiders'. The structure of preferences and the locus of decisionmaking authority within whatever organization we wish to consider the decisionmaker is clearly of great importance for predicting the 'shape' of objective functions in real world peasant systems. In particular, convexity, premised on monotonically diminishing marginal rate of substitution between goods (or characteristics) is often assumed by micro-theorists rather than justified. This criticism is more than nit-picking: in fact, individual's preferences and the pattern of authority over disposition of resources and distribution of outputs determine the objective function of a multi-person 'unit'. At the degree of generalization of this discussion - that is, without making explicit assumptions about authority and individual preferences - there is no basis for asserting convexity. A.K. Sen's essay on peasant farming (17.) is an exception on this count in that it establishes the desired convexity of the (family) utility function on the basis of assumptions about values and decisionmaking within the unit. All members are presumed to have identical utility functions characterised by non-interdependence and strictly declining marginal utility ($U_x'' < 0$). The family Decision Rule is to maximize the total utility of the group, which from the assumptions on individuals' preferences implies: a. egalitarian distribution of work tasks and outputs and b. convexity of the family welfare function. Apparently Sen had in mind the extended patriarchal Indian peasant family, for which these conditions may be a fair approximation of reality. But peasant systems are diverse, in terms of the appropriate decision unit and the relationships between individual and group, and blanket assertions on the shape of the utility function are not warranted. (This being said, I will have recourse to convex indifference surfaces for purposes of exposition below).

The importance of habitual or customary behavior, the impact of social values, taboos, etc. upon decisions taken within a cultural context will be dealt with anecdotally in the following section. Some useful points can be made at this juncture: 1. habit implies lack of deliberative choice - it may even imply a certain disutility of decisionmaking perse or strong aversion to particular forms of risk which led to establishment of habit in the first place. Habit can be construed in terms of utility analysis as the outgrowth of experience which has established the clear superiority of the characteristics associated with certain patterns of activity as oposed to alternatives. Habit may supress positive responses to 'available' activities by inhibiting perception or evaluation of information about them. 2. If certain activities conform with social norms or earn favor with society outside the unit, while other activities are at variance with norms, then the impact of a unit's behavior on its relations with the parent society can be considered as characteristics of the relevant activities, about which the decisionmaker has preferences. An attribute of activities is that they are socially approved, neutral, or disapproved; they may be characterized by intangible rewards or penalties. In the discussion of farming innovation, below, it will be shown that both the expectation of social reactions and the decisionmaker's valuation of probable reactions may determine both which people will innovate and which innovations will be most widely adopted. 3. In Western economics we accept the importance of interdependence of consumer tastes and the drive for status through visible improvements in consumption standards. It is likely in most peasant systems that farmer's subjective sense of wellbeing will similarly be affected by relative consumption levels of particular characteristics.

Labor is normally thought of as a source of disutility, but this proposition is misleading when applied to a generalized activity approach to decisionmaking. Work and leisure are not clearly distinguishable nor homogeneous. We can say that human time is a major input component of both farming and nonfarming activities and that characteristics of the time inputs have intrinsic value - positive or negative - to members of the decision unit. Time inputs should be differentiated according to characteristics along several axes of CSpace, (supra, p8).

The intertemporal implications of many peasant decisions have been mentioned. In the consumer preference model , purchases of durable goods could be thought of as producing a stream of dated characteristics. There is no reason why the analogy should not hold for peasant activity analysis , an important difference, however, being that we want to adapt time preference to be adapted to uncertainty. Activity level choices may be similar to economic models of portfolio selection under limited information. Decisionmakers have expectations, based on experience and new information, which they hold with varying degrees of confidence about the probability distributions associated with activities. Decisions are taken on the basis of an expectational efficiency frontier, several of whose characteristics dimensions are perceived measures of dispersion of valued characteristics. The utility function embodies loss functions associated with decisionmakers' affinity or aversion to various kinds of risk (supra, p.8).

C. CONDITIONS OF RESOURCE AVAILABILITY

Our consumer maximized utility subject to a straightforward linear constraint: money income. The typical peasant household (or other unit) confronts a complex set of resources availability-limitation conditions, especially when consideration is given to the totality of agricultural and non-agricultural activity choices consciously or habitually made. For each of the conglomerate inputs - land, labor, fixed and working capital - decisionmakers may possess stocks of their own, over whose allocation they have considerable discretionary authority, as well as access to additional types or amounts through commercial markets, barter agreements, or other socially determined modes of appropriation.

We recall from an earlier section that past allocation decisions affect currently disposable resources.

<u>LABOR:</u> The decision unit commands time inputs from among its constituents, but the supply of own-labor, in efficiency terms, is clearly a function of: 1. the size, age, sex, and health composition of the unit; 2. customary or otherwise sanctioned allocation of specific functions according to age, sex or other criteria; 3. reciprocal or custodial time obligations for agricultural or non-agricultural activities outside the unit. The 'unit' is in any case a fiction, and there may be peasant societies in which decisionmaking on time and other resource allocation takes place at so many levels and is so encumbered by custom that the concept of <u>a</u> decisionmaking entity may not be useful even for heuristic purposes.

Hired labor is available in many peasant systems, but seldom in a market situation where the individual buyer and seller are both price takers. Custom or bargaining may result in pay taking the form of cash, produce or reciprocal labor obligations; pay may be on a piece or task rate or be paid by the hour, day, month, etc. Both the rate of pay and the physical availability of hired labor are likely to vary according to task and season (and according to land tenure, population pressure and other features of the system). The ability of decisionmakers to hire labor implies the existence of opportunities for 'unit' members to offer themselves for employment in return for compensation. The nature and rewards of alternative kinds of outside employment, in con-

and costs
junction with the probabilities of finding different kinds of work, will enter the decision calculus.

Cooperative labor of several kinds is commonly used in East Africa; like hired labor, its availability - in terms of tasks, timing, amount, and type and magnitude of payment - may be determined by custom, authority, or agreement.

The availability of human time inputs to the decisionmaking unit can thus be seen as subject to mixed budjetary and 'linear' constraints, and complicated by the fact that characteristics of time inputs directly enter the utility function.

(Note: Knowledge, skills, and aptitudes - such as market information, managerial ability, and maunual dexterity - are part of the resource endowment of a decisionmaker. But the impact of these qualitative resources shows up primarily in the technology of activities: possession increases the productivity of other inputs in the range of activities over which the special capabilities are applicable. This would invalidate Lancaster's contention that activity technology is identical for all decisionmakers.

LAND: Conditions of land use and tenure take many forms in peasant systems, but we may usefully differentiate between two kinds of control over the disposition of land resources: first there is land which by inheritance, purchase, gift, bush clearing or another criterion is available to the unit to employ essentially as it wishes without interference from outsiders (This does not imply that such land rights exist in all farming systems). Second, the unit may have access to additional land by purchase, lease, rent, or loan from the community (eg. clan) or from other similar decision units. The terms of acquisition of rights to land use - temporary versus permanent; amount, type and timing of payments, etc. - are conditions of resource availability.

We note, in passing, that the location of plots, relative to unit members' dwellings, to water, markets, transport arteries, and other plots affect input requirements - especially time inputs - of activities involving the plot. These effects may be important determinants of decisions on the pattern and intensity of activities.

FIXED AND WORKING CAPITAL: MATERIAL INPUTS: Few points need be made about material inputs. First, since we are considering utility to be defined on the attributes of activities, then foodstuffs and other durable and non-durable consumer goods are intermediate inputs; second, it is possible that many material inputs can either be produced by the decision unit or acquired by other means. In peasant systems which have access to markets or highly developed internal exchange mechanisms for farming inputs and consumer commodities, the complexity of choice situations may be very great. Activity analysis of the peasant economy is especially complicated by the possibilities for substitution among non-identical inputs (for example manure vs. commercial fertilizer and metal vs. wooden share ploughs). Home production of inputs implies a particular set of intermediate sub-activities; generation of cash for purchased inputs implies a different set of prior money earning actibities.

CREDIT: Deferred payment for resources acquired from outside the unit exists in many forms and on various terms of repayment. It is doubtful that any farming system is totally without some kinds of future obligations created by current resource transfers. The kinds of resources available on credit, the extent to which they can be acquired on loan, and the structure of repayment are dimensions of resource availability which may be crucial to choices.

D. EQUILIBRIUM AND CHANGE

Having cast doubts on the sufficiency of the formulation of activities, preferences, and resource constraints of part I, we cannot generalize with confidence on efficiency frontier and utility function shapes and , ergo, on the uniqueness of maximization. But, as the last several pages indicate, our primary interest is not mathematical refinement ; rather it is to draw the analogy between the interaction of components in non-linear programming and the complex interplay of forces which give rise to peasants' resource allocation decisions. The central assertiong is that the structure of preferences of a decisionmaking organization (whose internal workings and relationships to outsiders must be understood); the input-output technology of agricultural and non-agricultural activities; and the nexus of resource availability conditions jointly determine peasant choices.

Uncertainty due to randomness and limited information implies a set of ex ante resource allocation decisions based on expectations, and an ex poste outcome for each activity which may have a different set of output characteristics from those expected. Just as decisions taken at one point in time, t_o, are a function of expectations based on the stream of past experiences, so too will the experiences of the period between t_o and t_1 enter the probability calculus which affects decisions at the latter point. Even peasant systems which appear to be economically stagnant are not characterised by unchanging decisions. Choic at one point in time is in part a servomechanistic reaction to unexpected occurences - 'successes' and 'failures' of past periods. Altered decisions resulting from 'elastic expectations' or unforseen changes in resource levels may be difficult to classify as innovative or non-innovative. We might define non-innovative changes as adjustments within the ex ante activity technology: new activity levels of old activities are chosen as expectations and resources change, leading to a new perceived or actual efficiency frontier. For example, the failure of a major food crop due to abnormally bad weather may lead to new decisions based on: 1. decline in labor availability in efficiency units, due to undernourishment; 2. felt need to provide sufficient stocks against future famine; 3. altered perception of the likelihood of repeated crop failure.

We could assert that a shuffling of operation levels of activities which figured in past allocation decisions is inherently non-innovative. However, many previously known but untried farming techniques - which have had zero activity vectors - come into use precisely through the adjustment-to-unexpected-outcomes mechanism just described. We would like to include as innovations any activities which are qualitatively or technologically different from any previously used.

A typology of inducements to adoption of new activity patterns was given on pages 5-6 and demonstrated geometrically in Footnote 5. The programming-derived peasant decisionmaking framework presents analogous sources of change through new preferences (including time preference and risk reactions), new information, acquisition of skills, or the availability of new inputs and activities which alter the efficiency frontier; and new conditions of resource availability.[8]

Innovation - the introduction of qualitatively new activities - has an opportunity cost in terms of activities foregone. One of the valuable features of activity analysis as a conceptual device is that it permits us to 'visualize' algebraically the way in which a new activity (given its input and output coefficients and relevant prices) influences the shape of the efficiency frontier along specific characteristics dimensions. Decisions to adopt new farming practices, partially or wholly replacing other agricultural or non-agricultural activities are incorporated as marginal adjustments in a complicated set of choices. Fig VI of Footnote 5. helps to distinguish the two necessary conditions of innovation adoption: feasibility and willingness. The decision-maker must perceive that a new activity is compatible with his resource limitations (point B" vs B"') and that it will enhance utility by its expected provision of characteristics (frontier AB"CEF vs AB'CEF).

Having argued that programming concepts are useful for understanding peasants' choices, we will demonstrate with illustrations from some prominent hypotheses from the literature on peasant farming.

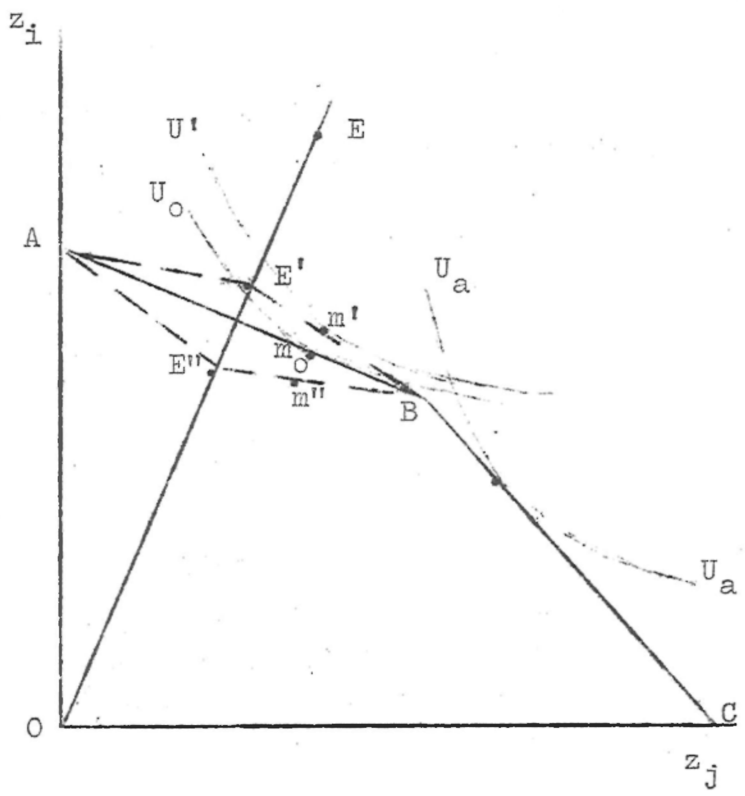
III. APPLICATIONS OF PROGRAMMING CONCEPTS

1. Non-Homogeneity of Decisionmakers: There is a considerable literature which draws on empirical evidence and deduction to discuss the distribution of types of decisionmakers within a system in terms of the quickness and extent to which they adopt 'available' innovations. Our approach makes it clear that differential adoption of single new farming practices or of innovations in general among members of a system can result from many different combinations of dissimilarities in preferences, resources, and perceptions of available activities (subsuming skill and information inequalities). A most important benefit of the programming perspective is that it highlights objective differences between units (for example: the number of adults in its 'labor force'; the amount of land available; current income and assets; access to credit; experiences and new information which underlie current expectations; and farm management skills as a function of education and special training). The objective differences between units at one point in time often go a long way toward explaining differential adoption of specific innovations requiring particular input combinations and technology and producing a particular mix of output characteristics. Although, by regress, objective differences may have their origins in psychological traits, it may still be misleading to label peasants as innovative or non-innovative personality types when differences in patterns of change adoption derive largely from factors not directly stemming from personality.

2. 'Rational rejection' and 'irrational adoption' of innovations: Figure II, below indicates three ways in which rejection of a new activity can be rational in the context of utility maximization.
a. If a new activity, described by the vector of characteristics OE, could be undertaken to the level OE', pushing out the efficiency frontier from its initial configuration ABC to AE'BC, then it still might not enter into the optimal set of activities if preferences for the two characteristics z_i and z_j at the margin were significantly different from the output proportions of the new activity. This is shown by the indifference surface U_aU_a.
b. If OE" describes the characteristics produced by the new activity operating at its maximum level, then it will not enter the optimal activity set because the set of characteristics which it can produce is objectively inferior to combinations attainable along the AB segment. c. if there is an indivisibility in the activity such that it must operate at the level OE or not at all, then the activity will be rejected as unfeasible, because it is not compatible with resource availability.

So-called 'irrational adoption' and 'irrational rejection' of innovations may result from mis-information or false expectations rather than irrational behavior. Fig. II serves as a vehicle for demonstrating the meaning of such behavior. Let AE'BC be the <u>expected</u> impact of a new activity on the efficiency frontier; with this expectation and the preferences described by indifference surfaces U_o, U', the decisionmaker includes the new activity in his 'action set', anticipating an equilibrium point (M') which is superior to the <u>ex ante</u> optimum, M_o. But the characteristics vector of the new activity may only be OE", and combining activities inproportions expected to produce M' will produce only M" which represents a loss of both characteristics compared with the prior equilibrium point M_o. (This kind of misapprehension, in reverse, is implied by the concept of irrational non-adoption: poor information leads to an underestimate of the benefits acruing to the use of a new activity).

FIG. II.



3. <u>Divisibility</u>: Divisibility has been stressed by Rogers and others (27, 28.) as an important determinant of adoption or rejection of innovations. In East African peasant agriculture widespread adoption of new practices has often followed small scale trials. IF peasants have limited information on which to base expectations or limited credulity of information from particular sources ; if in the past some innovations have not been succesful; and if farmers are reluctant to jeopardise fairly certain levels of food or cash crop outputs using standard

techniques, then we can understand the importance of trials (implying divisibility in time) at small scale (implying divisibility of resource commitment. The risk dimensions of CSpace take on major importance in this interpretation.

4. Diffusion: Diffusion is a temporal process by which the use of new activities spreads through a system of decisionmakers. It implies transmission of information: between 'change agents' and decisionmakers, or among decisionmakers themselves. We can classify three kinds of information flows important to the spread of adoptions: a. those which make a decisionmaker aware of an activity of which he was previously ignorant; b. those which enhance his ability to undertake an activity efficiently (for example, information on optimum combination of inputs or on sources of inputs); c. those which help to establish more confidently held expectations about input requirements and output combinations of an activity (for example, other farmers' trials).

5. Backlog: The discussion of farming practice adoption need not be confined to activities or modifications of activities which come to decisionmakers' awareness for the first time. Diffusion sequences, in fact, imply some time lag between awareness and adoption of new techniques: farmers commonly have some knowledge of practices without utilizing them. Some rationally rejected practices can comprise a backlog of potentially desirable activities whose use is inhibited by specific obstacles, including insufficient information upon which to base confident expectations; ignorance of techniques or skills required to undertake the activity efficiently; lack of access to crucial inputs, input prices, lack of finance ; lack or unattractiveness of markets for outputs.

6. Extension Services as Change Agents:

The primary functions of agricultural extension services are sometimes capsulized as education and persuasion: providing farmer decisionmakers with particular kinds of information, transmitted in a specific social context. The persuasive power of extension advice is a derivative of its educational impact, as long as the initiative for farming decisions rests with the farmer. Lectures, pamphlets, demonstrations and other extension media can be seen as providing farmers with information about the technology of activities - how to perform them and what combinations of outputs to expect from them. Given preferences, the short run objective is to change the farmer's notion of his activity possibilities frontier by: informing him of new practices; educating him in new farming skills; and producing demonstrations of activities which - presumably - reduce his uncertainty about the input requirements and output characteristics of novel practices.

Empirical work in East Africa, including my own, reveals two additional and potentially critical extension service functions. The first is to act as a catalyst of individual decisionmakers' preferences by strategically choosing social modes for presentation of extension advice. It appears, for example, that some peasants participating in group activity (such as a farmer's club) more readily adopt new practices than non-participants if group enthusiasm or momentum for change is stimulated which reduces or eliminates the individual's sense of the risk of hostile social reaction. In other words, stimulation of changes in group norms can be an effective substitute in some settings for stimulation of individual deviance from norms. A jointly undertaken trial , with sharing of input commitments and risks, may also help to overcome resistance of individuals whose fear of loss would stifle their adoption in isolation from the group. Note: empirical identification of the net impact of group activity on innovation adoption by means of comparisons is made difficult by the fact that the members of groups working with extension agents tend to be the more reponsive farmers.

The second critical service is that of liason among agents whose services are necessary [illegible] but only jointly sufficient to induce desired farming changes. In particular, specific extension advice may be complementary with the terms of availability of credit, purchased or hired inputs, and markets for outputs.

6. The Commercial Sector as Change Agent: Peasant economies are by definition not closed systems (see Wolf, p 1-4) and the nature of transactions between decisionmaking units within the system and between them and a specialized commercial sector is likely to be an important determinant both of the status quo ante and of the direction and pace of change. As mentioned elsewhere in the paper, a. the existence of markets for activity inputs and for farm produce; b. the pattern of price levels and fluctuations (and the incidence of cheating); c. the introduction of new inputs for farming or consumption; d. the effectiveness of communication of 'market signals'; and e. the physical location (and price differentials) of various markets : all have implications for the decisionmaker's expectation of attainable activity levels. Note: Marketing must be considered as an activity in itself, since it requires time inputs and produces characteristics as a social event. The act of choosing and purchasing in a market may itself give rise to utility.

7. Technological bias of innovations: The programming approach, stressing the interaction of resource limitations and activity technology with preferences, should be a useful vehicle for examining the input 'saving', 'using' or 'augmenting' biases of specific innovations. In a specific resources/prefernces context this is useful for predicting the kinds of innovations most likely to be adopted, for suggesting combinations of practices for public promotion, and for demonstrating the effects of individual activity changes on the entire system of activities.

8. Innovation in food crop and non-agricultural activities: Rural development policies and programmes tend to emphasize expansion of cash crop activities, largely neglecting the areas of food crop production and other household activities. Linking all activities in an activity technology to an efficiency locus brings out the potential importance for the level of marketed farm produce of innovations which increase resource productivity in any activity, permitting either sale of surpluses of food crops or transfer of 'saved' resources into cash earning activities. Clearly, the pattern of resources released by greater efficiency in non-farm activities versus the pattern of resource needs in cash cropping activities determines the overall impact of non-agricultural innovation.

9. Innovation combinations: One encounters arguments about the inefficiency of some individual farming changes, and conversely of the 'high-poweredness' of innovation combinations applied to single or technologically interdependent cropping activities. A programming activity set - including single and joint innovations as separate activities - would show, first whether joint innovations are compatible with quantitative and skill resource constraints, and second, the difference in magnitude of their expected contributions to welfare.

10. Customary consumption and production patterns and 'incentive goods': In every society custom and habit govern a wide range of decisions, replacing conscious deliberation as the basis of choice in some matters. But such behavior is not necessarily non-maximizing nor a disproof of the usefulness of the concepts of programming analysis. Customary behavior can be thought of as the incorporation of individual or group experience into utility maximization under one or both of the conditions: a. the history of each decision unit and of its parent community establishes a pattern of tastes and a wealth of knowledge about the activity combinations most likely to achieve the most valued set of characteristics under conditions of uncertainty; b. a negative valuation of the act of deciding to adopt new activities with highly uncertain outcomes. Custom is seen, in other words, as

a systematic form of risk lessening or as a form of risky-decision aversion. A catch in this logic is that customs, once established, stand in a two-way causal relationship to activity choices: customs both determine preferences and follow from them.

In many peasant systems purchased consumer goods (especially non-durables such as soap, tea, sugar, cloth, tobacco) and purchased material farm inputs (such as metal hoe, ox-drawn plough, and seed varieties) once introduced into the activity set may become part of customary patterns. Changing preferences for characteristics and the availability of goods and services with (subjectively) new or superior combinations of characteristics can give dynamic impetus to an economy, however. Several economists have emphasized the importance of 'incentive goods' for de-inertializing peasant agriculture (see no. 13, Hymer and Resnick). Their arguments center on the possible insufficiency of incentives to agricultural intensification in an economy where basic needs for food, clothing, shelter, and ceremony are easily satisfied but where purchased goods possessing highly valued characteristics combinations are not available. The narrow range of purchasable goods may consist of things which already compose part of the customary consumption pattern and have low utility at the margin or which are so high in price as to be beyond decisionmakers expectations of attainable purchasing power.

Taboo, an extreme form of custom, can be represented as [illegible] constraints on certain technologically feasible activities (for example, a religious taboo on doing farm work on Sundays restricts the supply of time inputs to farming tasks; if a crop must be planted before another one or by a certain date, we impose timing constraints on planting). Activities which are not taboo but which incur some form of social disapproval are represented in characteristics space by axes specifying type and intensity of sanctions.

11. Bases of Agricultural Diversification (Belshaw/Hall, no. 21, p7) Greater specialization in production of cash and especially export crops is urged as a vital part of economic development in East Africa (in Uganda greater specialization , according to official pronouncements, is to be accompanied by greater diversification of cash crop types). Through the medium of a programming model we can see a number of reasons why most peasants are reluctant to specialize beyond some point. (note: the typical family farm in developed countries produces a considerable proportion of its subsistence food needs).

a. The unit's resources may not be suitable to specialization. Qualitative land differences, either innate or resulting from rotational patterns, affect the suitability of plots for different crops; seasonal or other determinants of labor availability may impose maximum feasible activity levels on some crops.

b. The technology of activities may work against specialization: diminishing returns to variable inputs on a fixed amount of land may imply positive activity levels for more than one crop; climatic variations favor different crop patterns according to season; complementarities, such as different root depths of interplanted crops, or labor saving on land clearing and weeding with some kinds of interplanting, may work counter to specialization.

c. Finally, uncertainty and preferences are cardinally important for understanding diversification. First, peasants may prefer a broader to a narrower variety of food characteristics but may be apprehensive of getting variety through specialization in production of a few crops for market and purchase of most foodstuffs for consumption. Latent distrust of the market mechanism, and possibly an exaggerated perception of the risk associated with reliance on markets to provide basic food needs, appears to be one obstacle to greater specialization. The widespread practices of growing several kinds of food crops simultaneously (for example cereals, grams, root crops, and bananas) and of staggering planting dates for a single crop indicate a basic similarity between the peasant decisionmaker and the portfolio diversifying financier.

CONCLUSION:

Most of the ideas presented herein are in a crude form and require considerable additional thought; nonetheless, analogies to non-linear programming, the idea that preferences are for activity characteristics rather than commodities, and the notion of inherent non-separability of farming from non-farming activities in a study of peasant resource allocation decisions have helped me to grope toward an understanding of the process of agricultural innovation adoption in Teso and Bukedi Districts.

FOOTNOTES

1. Interdependence of tastes among decisionmakers is clearly an important determinant of consumers' preferences and their purchases. The concepts of 'snob', 'bandwaggon' and 'veblen' effects of market conditions for particular goods altering individuals' valuation of the goods can be accomodated by characteristics-preference notions if we relax the assumption that characteristics must be intrinsic to the good. Then we can assert - with plausibility - that an imprtant characteristic of a commodity or an activity may be the decisionmakers perception of its consumption by others and the effect of this perception on his own utility derived from the good/ activity.

2. With linear homogeneous activity vectors, a necessary condition for the existence of a non-trivial programme solution is that the determinant of the A matrix be zero.
Strictly speaking, the matrix formulation of a closed input-output system would be $x=Ax \pm F$ (F is the final bill of goods)

3. These assumptions guarantee convexity, but not strict convexity of the utility function. If $U'(z_i)/U'(z_j)$ is constant over some range of z_i/z_j values, then the utility function will have one or more linear segments. This has two implications which, although no more than curiosa, can be mentioned; first, there may be infinite optimal solutions if tangency should occur between a segment of the efficiency frontier and a linear segment of U(z); second, the existence of linear segments may imply discontinuities in the marginal rate of substitution about the end points of the linear segment, in which the usual techniques of non-linear programming solution, using the Kuhn-Tucker optimality conditions, will not be applicable and someone wanting actually to solve such a problem would have to employ integer or perhaps some other technique. In fact, simple linear programming techniques might be applicable.

4. The CONSUMPTION TECHNOLOGY (Lancaster's term), expresses the set of all possible - not necessarily feasible - consumption activities and the relationship between goods(inputs) and attributes (outputs) of activities. It is described by the functions $x=Ak$ and $z=Bk$, and more specifically, by the dimensions of the A and B matrices and by the a_{ij} and b_{ij} coefficients. There is no apriori reason to believe that the number of activities, goods, and valued characteristics are all equal ($m=n=r$). Lancaster hypothesizes that the consumer in a Western industrial economy confronts a choice among many more goods that there are characteristics. The implication is that many goods possess similar - but not identical - sets of propoerties, resulting in a high degree of intrinsic substitutibility among goods: a wide range of choice. We find, for example, forty-three 'makes' of automobile produced in the United States, each of which has more than ten'models'. Even excluding imports, there are over fourhundred car models available to the consumer. Subsets of these possess similar bundles of characteristics (for example, speed, size, comfort, prestige) in slightly varying magnitudes and relative proportions. Although a more readily divisible good than automobiles might provide a more compelling example , we can conclude that the range of goods available which can produce a given vector of characteristics is typically large in some economies. In terms of consumption technology, this implies $n > r$. In terms of the real world we can only speculate about numbers of characteristics and numbers of goods and services, the task of enumeration being rather cumbersome. It may be that the aggregate numbers of goods and characteristics confronting the consumer is less important for understanding his decisions than the number of goods which are substitutible as sources of particular characteristics combinations.
But, returning to algebra, if $n > r$ then we are dealing with non-square matrices. Adopting the fiction that each activity consists of one good, we can consider the non-linear programming problem

with regard only to n and r. Then we can set any combination of (n-r) goods consumption levels to zero and use the resulting r by r matrix of transformation to solve iteratively for the optimal consumption levels of the r remaining goods (nb. some of these may turn out to be zeros as well). As we expect in a situation where many commodities are substitutible in terms of their intrinsic characteristics - and as we expect in a programming problem with more activities (goods) than constraints (objective function elements), some activities/goods are not operative/consumed in the optimal solution. Unfortunately with a non-cardinal objective function, we cannot even conceptualize the grand-optimal solution (without recourse to revealed preference) by applying an iterative procedure with changing combinations of (n -r) 'slack' commodities because we cannot directly compare utility levels produced by the n!/r!(n-r)! different quasi-optimal solutions to identify the dominant one.

The importance of all this for study of peasant decisionmaking is that the converse case from the one cited, namely the case $n < r$, probably describes the activity technology underlying choices of most African farmers. With relatively few commodities available which possess the same properties, there is less inherent substitutibility among goods to get a more highly valued combination of ta particular set of characteristics. In this case, the conceptual programming problem requires that (r-n) characteristics be set to zero and the system solved by use of the resulting n by n matrix of coefficients. The optimal solution will be a corner solution in CSpace, with some characteristics excluded. Given preferences, the less is intrinsic substitutibility among commodities, the less likely it is - ceterisparibus - that small changes in relative commodity prices will have a major impact on the relative proportions of commodities in the equilibrium activity mix (this is a characteristic feature of corner solutions). Introduction of new commodities in this situation can potentially have a major impact on decision changes . . The concept of 'incentive goods' (as commodities which possess superior combinations of characteristics to old commodities - per unit cost - or which embody wholly new properties) as an important inducement of agricultural production changes appears to .. be brought out well by the notion of an $r > n$ consumption technology with preferences defined on properties.

5. Referring to Figs. III-VI, we can briefly indicate what each of these change inducers 'looks like' in a planar slice of characteristics space. (1) achange in prefernnces is shown by a change in the shape of the indifference curves for z_i and z_j. In fig III, the change in tastes reflected in the shift from U_1U_1 to U_2U_2, passing through the original optimization point A indicates an increase in the subjective valuation of z_i relative to z_j at that point. The new equilibrium point after adjusting purchases is B. (2) An increase in income moves the entire efficiency frontier away from the origin, parallel to the original frontier, as seen in Fig. IV. Fig.V. shows the effect of a decline in the price of good x_k, which gives rise to characteristics z_i and z_j in proportions indicated by the slope of the ray Ox_k. In the case shown, the efficiency frontier is expanded by a decline in p_k. The effect of a price change on equilibrium conditions will depend upon the extent of price change, the characteristics coefficients of the good, and the strength of income and substitution effects in the utility function. (3) The introduction of a new commodity which embodies both charatteristics becomes an additional activity which may or may not affect the efficiency locus, depending upon its price and characteristics coefficients. In Fig. VI, starting with the efficiency locus ACEF, we add a commodity represented by the vector O'. If by expending the entire budjet on this good, the consumer can only attain point B' , then good x_b will be excluded from the optimal solution because a feasible combination of goods x_a and x_c

(along the segmentAC) can provide more of both characteristics. If, on the other hand, the budjet constraint permits consumption of x_b to the point B", then the good will be included in the efficiency locus and may be consumed, depending upon the shape of the indifference surface. (4) Increased 'efficiency of consumption', achieved either through better information or improved skills, can be seen by means of the same diagram. If activity x_b existed but was formerly unknown to the consumer, then ne awareness of it can expand the set of feasible characteristics vectors from the AC segment to the superior set AB"C. Likewise, acquisition of skills which increase the characteristics outputs produced per unit of input of a good can shift the efficiency frontier from AC (where activity x_b was not part of the efficiency frontier) to AB"C.

Fig. III

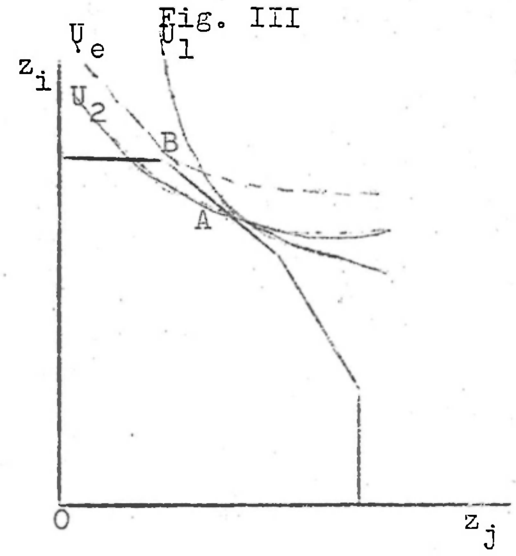


Fig. IV

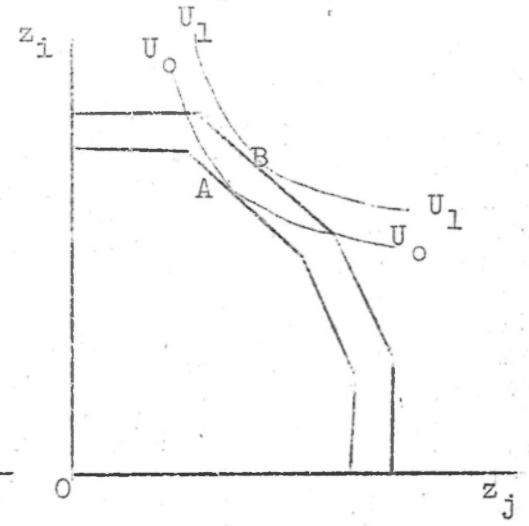


Fig. V

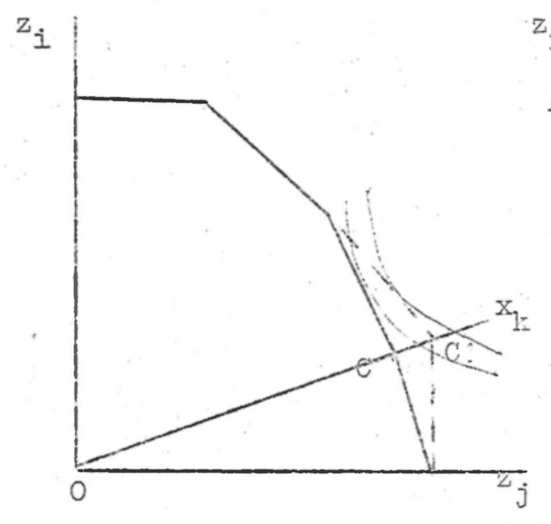
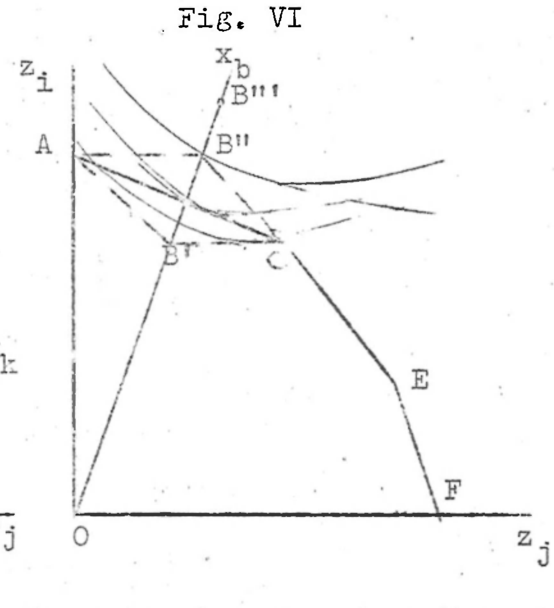


Fig. VI



6. By 'farming system' we mean the natural,cultural, and agricultural ambient within which a decisionmaking entity operates.

7. That is, one in which decisions are based not only on probability distributions of variables, but also on limited confidence in one's expectations of probability distributions - linked to his risk affinity or aversion.

8. Increase in the price offered for marketed agricultural produce or wage increase have the effect of expanding the resource base and pushing out the efficiency frontier.

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