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DECISION-MAKING AND AGRICULTURE

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Contributions of Economists to a Rational-decision-making Process in the Field of Agricultural Policy

In both socialist and non-socialist countries, governmental units use huge amounts of resources in amassing information, analyzing it, and reaching decisions on the problems before them. And, in private sectors, producers and consumers also use large amounts of resources to make decisions on, among other things, production, consumption, saving, and generation of human capital which are interrelated with public decision-making. Despite its obvious empirical and economic importance, the economics of public decision-making and management is relatively neglected; this neglect creates the opportunities to contribute discussed in this paper.[1]

An underlying unity emerges when we examine managerial and decision processes which transcends the developed/less developed, the micro/macro, the public/private, and, within the public sector, the centralized/decentralized spectra. This unity permits us to draw on a wide range of experience in studying public decision-making.[2]

In asking me to prepare this paper Professor Dams added the subtitle (The Position Between Adjustment Engineering and Critical Reflection on Values) and referred to a book about values and economists which I have co-authored.[3]

PART 1

Decision-Making and Management – A Summary Survey

This paper is written on the premise that it is important to be efficient – to be economic – in using the large amounts of resources and money devoted to public problem-solving concerning agriculture.

Management and decision-making are performed by more or less separate units or enterprises within an agency, firm or house-hold.[4] Enormous amounts of resources and inputs are used in these units.

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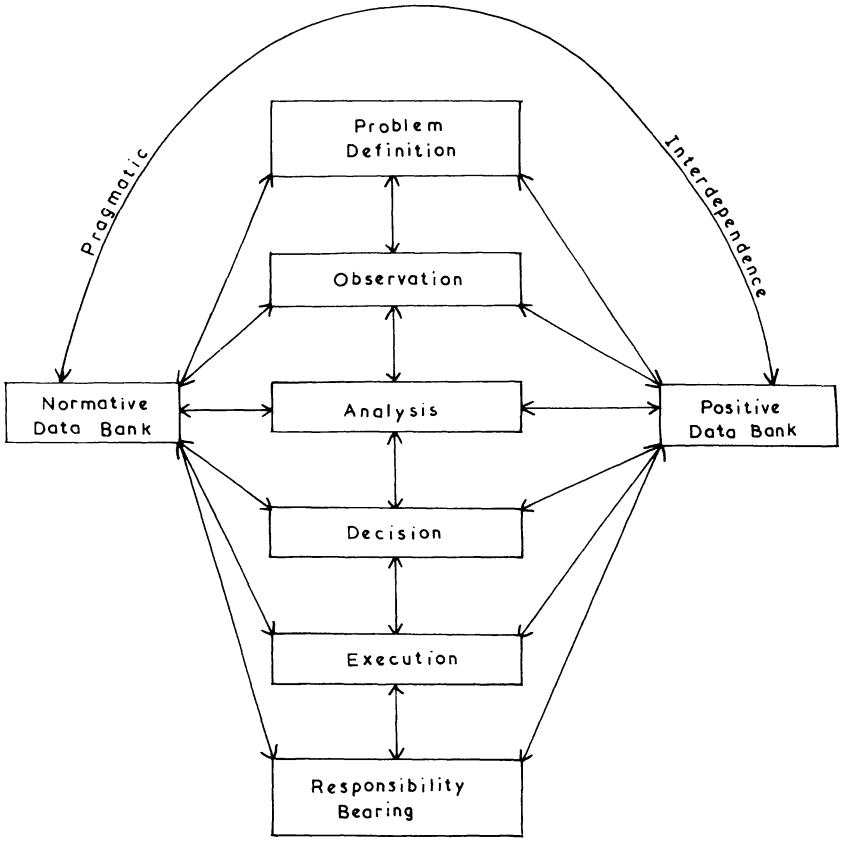

FIG. 1.[5]

The regulatory governments of the free enterprise, decentralized democracies devote high proportions of their budgets to decision-making and management. Socialized governmental units, which produce goods and services as well as regulate and control, devote smaller proportions of their budgets to decision-making and management but the absolute amounts are still large.

The processes whereby problems are defined and solved are behavioral. Hence, understanding managerial and decision-making units requires an understanding of human behavior. As in Figure 1, the behavior to be understood includes: (1) problem definition; (2) data and information acquisition, storage and retrieval; (3) analysis; (4) decision-making; (5) action, and (6) responsibility bearing. Each of these will be discussed in the following sections which will show how (1) economics contributes to performance of each function, and (2) economics can be used to increase the efficiency with which managerial units perform each function.

The crucial role of problem definition

Problem definition is crucial for decision-making units. Problems are defined in terms of both positive and normative information, the latter being both monetary and nonmonetary.[6] The existence of a meaningful problem implies some possibility, at least, that a decision rule could process the relevant positive and normative information into a prescription which would materially improve the existing problematic situation. In a study of the managerial processes of 1075 midwestern U.S. farmers (The Interstate Managerial Study, *IMS*), the structured questions used did not deal with problem definition or with the processes whereby farmers acquire and use normative information.[7] Fortunately, the IMS questionnaire contained sequences of non-structured, open-ended, probing questions. These revealed enough about problem definition for IMS researchers to see their error.[8]

Post IMS experiences with public decision-making units indicate that problem definition is of similar basic importance in their activities.[9] A related conclusion is that problem definition and solving is an iterative, adaptive, interactive process. When the investigator of a problem is not the decision-maker, the iterative, adaptive problem-solving process must also be interactive because decision-makers and affected persons are sources of information to investigators.[10]

Another important lesson growing out of the IMS experience is the distinction between kinds of information and problems. Initially, price,[11] production, new technology, institutional and human problems[12] were defined. Responses of the 1075 farmers to open-ended sequences of probing questions revealed, eventually, that these five "kinds of problems" were not problems at all; instead, they were kinds of information. Specific problems about which decisions are made, it turned out, typically require most of the five kinds of information for solution. Further, IMS research and subsequent experiences indicate there is probably no *stable* classification of problems for individual farmers or, for that matter, nations and regions, programs, and projects. The domain of each problem is described with a mix of information quite unique to each new problem.

Before leaving the subject of problem definition, we should discuss the word "paradigm" which is so fashionable these days. Kuhn, in his book on scientific revolutions,[13] noted that the problems before a scientific discipline sometimes change so drastically that a scientific revolution is required. As I see it, more or less minor paradigm revolutions are continuous for problem-solving researchers and decision-makers with each such revolution requiring a unique mix of contributions from various disciplines.

Whether a specific problem is macro or micro, public or private, etc., the efficiency of a decision-making unit depends on its ability to (1) define the problem and judge what information is required to solve it; (2) understand the statistical, technical, and human aspects of the process of acquiring, assembling, and storing the information; (3) convert normative and positive knowledge into problem-solving prescriptions; (4) execute decisions; and (5) monitor and bear responsibility for decisions made and executed.

Data acquisition (observation) storage and retrieval

Each type of information needed to solve a problem tends to be generated by a specific discipline such as, say, economics, sociology, political science, soils, crop husbandry, etc. IMS researchers found that midwestern farmers would use over 200 categories of information in solving problems of reorganizing and operating farms under the original five categories.

Further, it is now noted that there are three dimensions involved in the five general types of information considered. The difference between new technology and production with existing technology is in the *time* dimension, while the difference between the other four and price information is in the *positive/normative* dimension.[14] Basically, there were three broad categories of information (institutional, technological, and human), each existing in the past, present and future tenses and in the normative/positive dimension.

Kenneth Boulding, like IMS researchers, divides a decision-maker's positive image of his environment into the human, technical, and institutional and then sees superimposed upon that image an image of the values attached to the elements of the positive image. Further, he argued that the processes

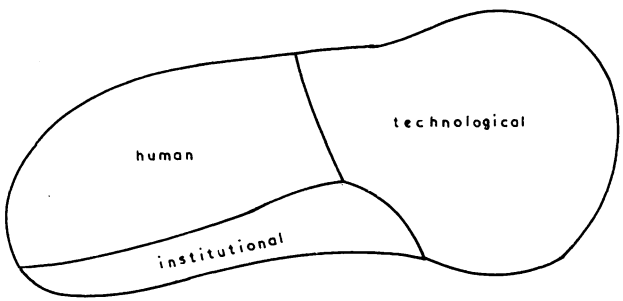

FIG. 2. Boulding's Image

whereby the two images are formed, "though there may be differences between them, are essentially similar".[15]

The kinds of information useful in defining and solving problems can be outlined with a three-way table as in Figure 3 below.

	Positive			Normative		
	Past	Present	Future	Past	Present	Future
Technical						
Institutional						
Human						

FIG. 3.

Prescriptive knowledge which is not diagrammed above[16] is functionally related to positive and normative information via decision rules (strategies). The normative includes both monetary and non-monetary values. Decision rules or strategies are considered in the Richardson, *et al.* paper on farm-level decision models presented at this conference. They, of course, deal mainly with the decision step in the total process of management or decision-making.

The IMS studied the processes whereby managers acquire, analyze and use information on prices or monetary values. It also measured utility cardinally.[17,18] One emphases was on how information on past and present prices is processed into price expectations. A quickly learned lesson was that the price expectation models developed by statisticians and econometricians were far too specialized on statistics to cover what farmers actually do.[19] Midwestern U.S. farmers were so keenly aware of price-making forces that they took into account competing and complementing products, the influences on prices of governmental programs, inflation, changes in demand, war, labour union activity, monopoly, taxation and subsidy programs. The behavior of farmers forming price expectations is much too complex to be modeled with simple (or even more complicated Nerlovian type) distributed lag models.[20] M. Lerohl has developed price expectation models based on distributed lags *and* other kinds of information used by farmers; these have performance characteristics superior to or at least as good as distributed lag models.[21]

The attention given to how farmers form price expectations was not matched by comparable attention to how farmers form expectations about non-monetary values. This was a basic mistake which should not be forgotten by students of public decision-making and private managerial activity.[22]

The lesson immediately above leads to another. In order to understand fully the acquisition of knowledge by decision-makers and, hence, to be helpful to them in their quest for knowledge, one must be philosophically flexible. Decision-makers *do form both* normative and positive expectations. Philosophic positivsm (often incorrectly designated *the* philosophy of science) is based on the metaphysical proposition that there are no normative experiences to use in developing descriptive normative knowledge. Fortunately, there are other respectable philosophies which grant the possibility of objective knowledge of the normative and prescriptive. These include pragmatism and various forms of normativism. *Pragmatic* investigators believe that positive and normative information depend upon each other mutually in a problem-solving context. In U.S. agricultural economics, important productive workers who at least partially follow or followed this point of view include John R. Commons, L. Salter, Richard T. Ely, Kenneth Parsons,[23] John Timmons, Rainer Schickele, Erven Long and many more. The econometrician and theorist, now pragmatic, Georgescu-Roegan recently recognized[24] there is much to be said for the point of view that normative and positive information are interdependent. However, case studies indicate that normative and positive information are not always so interdependent that it is always necessary for positive truth to condition normative truth and vice versa.[25]

The IMS experience, the Nigerian and Korean studies,[26] and many

consulting experiences indicate (1) the general inadequacy of assuming answers to normative questions in a conditionally normative way in order to proceed with problem-solving, but (2) that this approach works in many instances. Gunnar Myrdal followed this approach in Appendix II of *An American Dilema*[27] and, in so doing, made U.S. policy-making more rational. Kenneth Parsons fears the conditionally normative approach leads to "a reversion to the medieval view that the world of thought and action should be organized around assured values presented to mankind as dogma",[28] a view empirically supported by the existence of dictators (both right and left) and demonstrators (again both right and left) who try dogmatically to force others to embrace prescriptions based on values placed beyond the tests of logic and experience.

With respect to empirical normative knowledge, I find G. E. Moore's *Principia Ethica* (1903) most instructive, as did the late J. M. Keynes.[29] Moore demonstrates to my satisfaction the possibility of normative primitives to use (in the manner of the linguistic analysts) to convert analytic statements into synthetic (descriptively empirical) normative statements.[30]

We note that Figure 1 has (1) positive and normative information banks, (2) a pragmatic information feedback loop, and (3) feedback arrows to cover prices, political processes, press, and research and education as components of an information system. It is sufficiently eclectic to cover any philosophy, discipline, source of information or technique.

In IMS research, mechanistic expectation models of the type discussed earlier for prices were hypothized to be used by managers in forming expectations concerning technology, institutions and human behavior. This hypothesis did not survive pretest of the IMS field questionnaire. Expectation models for technological and institutional change used by midwestern farmers were related to past data and conceptual ideas and theories were used though not as systematically as in the case of price expectation models; apparently, sociologists and political scientists teach farmers less (or have less to teach) about institutional change than economists had to teach about price changes. Neither farmers nor academicians seemed to have highly articulated, conceptual systems for predicting technological change. Open-ended, probing questions failed to reveal much about how farmers form expectations concerning human behavior despite the fact that the questions were designed by a social-psychologist who devoted several unproductive months to tabulation and analysis of the answers.

To my knowledge there is no significant literature or research on how public decision-makers form expectations (normative or positive) with respect to technical, institutional and human change.[31] Presumably some of the above applies to public decision-makers as well as to farmers. My experiences with the Office of Technology Assessment, U.S. Congress, the U.S. National Academy of Sciences and the U.S. National Science Foundation and with non-U.S. agencies including FAO and IBRD indicate that study of their staff work and committe activity would cast some limited light on the public formation of technological, institutional and human expectations.

The price system is an important source of normative data and information

for both public and private decision-makers. Other important sources of such data and information include political processes and the press where these are free enough to permit the origination and feedback of reasonably "true" information from affected persons to decision-makers. Governmental information systems serve both private and public decision-makers. Highly centralized economies, right or left, tend to prevent the market from operating a price information system, suppress political process, and control educational systems and the press to prevent them from feeding back non-monetary normative information. They also often fail to provide substitute ways of furnishing such information to their decision-makers and, hence, suffer from poor decisions. Many centrally organized economies use local organizations of farmers, laborers, youth military personnel, other groups, etc., for feedback and control purposes. Whether or not such organizations are feedback mechanisms for information or merely steering mechanisms by which the central establishment "runs" the system is questionable – perhaps, they generally play both roles with the need for the feedback roles by action agencies being reduced in economies with operating price mechanisms, free presses, and open political and educational processes.

In his Presidential speech at the American Agricultural Economics Association last year, Bonnen[32] drew heavily on the work of Edgar S. Dunn[33] on social information processing and statistical systems which is based, in turn, on the work of information theorists and cyberneticists. Information theorists and cyberneticists concentrate on positivistic information acquisition (monitoring), storage (banking) and what they call processing (which is similar to, but not the same as, analysis and decision-making) as conceived herein. Figure 4 presents an information theory point of view. The *monitor* in Figure 4 is the *observer* in Figure 1. The *information processor* is both the *analyser and decision-maker* while the *effector* is the *executive.* The feedback from the

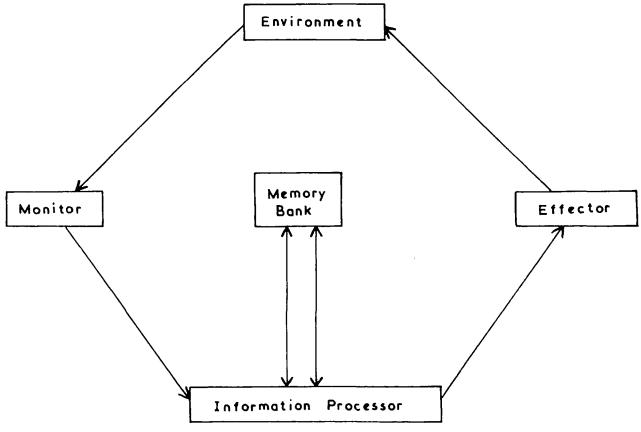

FIG. 4.

environment to the information processor via the *monitor* handles the *responsibility bearing function.* The memory bank does not distinguish between normative and positive knowledge. Dunn's discussion of information processing does not deal explicitly with how normative and positive information are processed into prescriptive information as he treats values and goals simultaneously without differentiating sharply between the normative (good and bad) and the prescriptive (right and wrong) in the C.I. Lewis sense.[34] While Dunn stresses the need to deal with the normative and prescriptive, his epistemological discussions are far from explicit.

There is an economics for deciding how much information of each kind is optimal in solving a particular problem. Knight's early but now obsolete distinctions among risk, uncertainty and certainty are relevant here.[35] A. G. Hart argued that Knight did not distinguish between risk and uncertainty on the basis of having *more than one* probability distribution to each of which is attached a probability in the case of uncertainty and *only one* in the case of risk. Hart noted that one could always compound two or more probability distributions into one by using the probabilities attached to each as weights but argued that it *might not pay* to compound at a point in time as an improved compounded probability distribution might be obtained later at an increase in cost less than the increase in value.[36] In so arguing, Hart anticipated Wald's work on sequential analysis which is now more or less subsumed under "pooled sample analysis".[37] In sequential choices between two alternatives, there are three alternative conclusions at any stage in acquiring information of a given type: (1) accept the first alternative, (2) accept the second alternative, or (3) continue acquiring information (learning). These three conclusions begin to focus attention on the economics of setting specifications for choices, i.e., on which alternatives are being considered and on what probabilities of errors of the first and second kind are acceptable. Setting specifications involves matching the cost of additional information against its value; *this is the economics of it.*

As some of both the marginal costs and marginal values are likely to be non-monetary, the economics of setting specifications in choosing between hypotheses is more akin to consumption and welfare than production economics. In any event, managerial and decision-making judgment with respect to acquisition of knowledge requires knowledge of the value (non-monetary as well as monetary in the context of the problem[38]) of the kind of knowledge being acquired.

Post-Wald risk is a situation in which specifications for a kind of knowledge have been met. Uncertainty, in turn, has to be divided into two parts, i.e., (1) a learning situation in which the specifications are not met but in which it pays to meet them and (2) situations in which it does not pay to try to meet the specification. The latter includes cases for which neither information acquisition nor decision takes place as well as situations in which outside circumstances force decisions. IMS researchers defined these situations as risk, learning, inaction and forced action.[39,40]

*Analysis (Use of Information)** – Another aspect of problem solving or function of management is the processing of primary data (both normative and positive) into secondary data and information. The domain of a problem tells us what is needed from what disciplines. And, the theories of the disciplines both tell us what data are needed and convert that data into information.

Economic theory also has the potential value of being helpful in defining optimal ways of solving a problem. Decision-makers economize when deciding, for example, that greater use of a particular biological theory has a greater pay off than, say, the use of a particular part of Keynesian theory.

Figure 1 shows two-way arrows among all the six functions of management, which indicates that the optimum amounts of observation and analysis are determined by an equilibrium among all six processes.

An orientation to economic theory both increases and decreases managerial efficiency. Efficiency is increased by bringing to bear the powerful analytical apparatus of economics on problems but may be decreased by the resultant possible neglect of other analytical apparatuses and concentration on the disciplinary *problems* of economics to the neglect of the practical problem.[41] Currently, economists are contributing their powerful analytical structures to the analysis of public problems involving human capital formation, family planning, and induced technological and institutional change;[42] hopefully, disciplinarians interested in these subjects will help economists make their contributions but prevent them (the economists) from uneconomically attempting to explain, originate and implement *all* human, technological and institutional changes when others may be able to do part of the job at lower cost.

Economists who use their theory both to define and solve problems must be sensitive to the problems which the market creates but cannot solve as well as to the problems which can be solved with market adjustments. Both of these are in addition to those originating outside the market. As a market system operates through time, those who can save get richer while those who must "eat up" capital to live, starve in a pareto-optimal way! In cases of inappropriate ownership patterns, the solution is a redistribution which hurts some in order to benefit others. In other instances, economies are simply out of economic adjustment and the resultant "problems" can be solved by mutually advantageous (pareto-optimal) trades among producers and consumers.

Dunn, in my opinion, unwisely designates progress through market solutions as economic and through non-market solutions as social. The distinction is unwise, because it is largely a distinction between private and public decision-making both of which have both economic *and* social significance.[43]

Among the problems which arise from market operations is the tendency of market-oriented agricultural economies to produce more output than can be sold at prices which equate marginal earnings with the marginal cost of acquiring resources.[44]

* Perhaps this function should be called synthesis rather than analysis as primitive terms (normative as well as positive) are used to convert analytic into discriptive information.

Decision-Making – The decision-making function of management is so important that management is often referred to as decision-making. A decision is a prescription of "what ought to be done" to solve a problem and, as such, is a function of both positive and normative knowledge, the functional relationships being the decision rule or strategy.[45] Some prescriptions are more risky than others. When decisions are viewed as above, it is difficult to use Knight's simple ideas of risk and uncertainty[46] even if modified to take account of Wald's sequential analysis[47] which tends to deal with one kind of positive rather than prescriptive knowledge. Risk is with respect to a decision, not one kind of knowledge going into that decision.

Interactive iteration is characteristic of problem definition and solution. Normative preconditions for maximization tend to be established in the process. These include: (1) establishment of a normative common denominator (CD) of all the goods and bads encountered in connection with the problem, this CD being necessary before maximization is mathematically possible, (2) if the decision will hurt some in order to benefit others as many housefold, family-farm and corporate private decisions and most public decisions do (at least in non-centralized economies).[48] an interpersonally valid CD, (3) establishment of the second order conditions mathematically necessary to assure the existence of a maximum in the CD, and (4) agreement on the decision rule to use. In the typical problem-solving exercise, a high proportion (over half) of the effort is devoted to establishing these normative preconditions and the positive constraints and consequences of alternate solutions. Initially the mode is not a maximizing one though it ultimately becomes so in most cases.

Attempts of economists to introduce maximization computations into decision-making are often premature and tend to foreshorten investigation of technical, institutional, psychological and social processes. The result is lost credibility for economists and economics – i.e., until the necessary normative and positive premaximization work is done, maximization cannot be reliable.

In order for a decision process and model to be credible, flexibility and generality are required with respect to: (1) types and sources of information – normative, positive and, eventually, prescriptive knowledge are required from any discipline (technical, institutional and humanistic) relevant to the domain of the problem, (2) philosophic orientations so as to permit work with normative, positive and prescriptive knowledge, (3) the use, non-use and delayed use of maximization, (4) use and non-use of such specialized techniques as linear programming, Cobb–Doublas analysis, input/output analysis (I/0), probabilistic estimation of the parameters of simultaneous equations from time-series and cross-sectional data, benefit/cost analysis, program planning and budgeting (PPB), program evaluational and review techniques, (PERT), deterministic adaptive models, etc., and (5) interaction with *people* (*decision-makers and affected persons*) involved as sources of positive and normative information which amounts to using indeterminate adaptive models.

General systems-science simulation approach (GSSSA) models, in my view,

hold great promise for helping public and private decision-makers solve problems. This approach requires that generality and flexibility be maintained. I want to stress that GSSSA is an *approach,* not a technique. Recently substantial progress has been made with this approach in iteratively and interactively (adaptively) modeling the multidisciplinary domains of problems so as to utilize the computational efficiency of modern computers. Specialized techniques such as recursive linear programming or other recursive models and deterministic adaptive maximization models provide components which become parts of GSSSA models, if needed. Both formal (machine) and informal (committees or single person) components can be used as needed.[49] The same is true with respect to maximizing components. Utilization of computers is an incidental to the approach though the efficiency of the computer often frees both money and scarce professional resources for pursuit of flexibility and generality.[50]

In the following paragraph we deliberately discuss evaluations of models and decision efforts together as the truth and validity of a prescription depends on the truth and validity of the analytical and empirical content (or structure) of the model generating it.

Evaluation of a total problem-solving model or decision process in terms of its riskiness is far more difficult than relatively trivial evaluation problems in statistical texts. Complete models of problematic domains necessarily contain both human and less human (mechanical, mathematical and analytical and/or empirical) components. Decision-making efforts also involve such components.[51] Decision-making systems may be open in the sense that energy (more generally low level entropy) enters the system so that growth is possible. Among the instrumental resources which low-level entropy can produce are positive, normative and prescriptive knowledge. Growth and development result from the improved decisions based on such knowledge, some as a result of improved market decision – others as a result of improved non-market decisions. The output of a decision unit is a prescription based on (1) many kinds of positive and normative information both empirical and analytic, (2) adaptive (iterative and interactive with *people*) attempts to find a moderately usable CD to use in measuring disparate non-monetary costs and values conferred and imposed on different *people*, and (3) adaptive (iterative and interactive with *people*) attempts to arrange alternative acts in the order of their decreasing advantage as determined by an iteratively sought decision rule.

In general, the decision process and image (model) of a problematic domain involves an acceptable degree of risk to the decision-maker if:

(1) the decision-maker is ready, willing and able to act *and* if
(2) the costs of further improving the image or model (in the broad sense) exceed the value of contemplated improvements with respect to the eclectic tests of truth: coherence, correspondence, clarity, and workability.

Here is the key (1) to understanding a contribution of economics to rational decision-making and (2) for distinguishing between acceptable risk and uncertainty, the latter of which can be broken down into learning (more

adaptive iteration and interaction), forced action[52] and inaction. There is an economics of matching added costs against added returns in setting specifications for decisions. How tight (conservative) or loose the specifications for an acceptable decision or problematic conceptualization should be is, in this view, influenced by how efficient the five functions other than decision-making are performed.[53]

The Executive or Action Function – Schools of business, military and public administration are likely to be more concerned about this function than economists. Traditional farm management men and farmers are likely to know more about it than production economists. And practicing public administrators, private entrepreneurs and housewives are probably the least likely to forget its importance.

Decisions which cannot be executed are of little value. More fundamentally, ability to execute and the required accuracy of decisions are interdependent. Still further, much execution is carried out by people who are essential sources of information in the managerial processes.

When the solutions of problems turn out to be technological, institutional and/or human change, execution requires special skills in these areas. Plant breeders and agronomists understand the processes of creating new varieties and cultural practices; political scientists, lawyers and sociologists – institutional changes; and educators and humanists – human changes. While changes which solve problems maximize human interest, in some sense, economics should not be expected to bear the burden of *explaining* the origin of such changes or of *seeing to it that they happen.*

Stress on administration to the exclusion of other managerial functions is often uneconomic. And, stress on one kind of administration to the exclusion of other kinds of administration and other managerial functions can be even more wasteful. We often find unproductive competition among administrative specialists rather than coordinated use of mixes of special administrative skills appropriate for executing the solution of specific problems based on all six managerial functions.

The roles of control and power in execution are important from the standpoint of executive efficiency. If complete objectivity with respect to normative, positive, and prescriptive knowledge could be reached, we would have consensus and there would be no need for power and control to *enforce* decisions which damage some in order to benefit others as everyone would agree.[54] However complete objectivity – i.e., agreement on positive and normative information, the preconditions for maximization including a decision rule, and on the prescription – is so expensive it is typically uneconomic. In the absence of complete objectivity, *use of force* – military, political, administrative, social, market power based on property ownership, religious – *is necessary to execute decisions.*

Imperfect knowledge and the need for executive power seem to be universal. Market decisions rest on political covenants which preserve the ownership of certain "rights" (and privileges) as private property. Non-market adjustments are based on other similar covenants or distributions of power among military and police officials, party members, civilian administrators and politicians.

Where the ownership of power and control is uncertain, there is danger of conflict from challenges which lead to tests of power on the field of battle, in the market, between personalities or in such political arenas as the national, local bureaucratic, academic, corporate, tribal, and familial (household and/or firm and extended). On the other hand, the ownership of power and control may be so definite that no challenge or conflict is possible and problems involving concentration of power go so long unattended that eventual change becomes catastrophic.

When the ownership of power is highly concentrated in the hands of decision-makers and executors while affected persons are powerless, meaningful feedback from affected persons is inhibited and the managerial process is deprived of an important interactive source of information. This occurs in authoritarian families, business and governments; it also occurs in free market economies with highly skewed, fixed distributions of property ownership. Prior to World War II, the Ford Motor Company suffered from this difficulty. Hitler's Germany and Stalin's USSR also suffered. In much of South America, property ownership is both skewed and highly stable. Authoritarian regimes (public, private, and mixed) are deprived of needed feedbacks if affected persons do not own the right to send messages. The ability to send messages depends on rights to participate in political activities, in the market, and to receive and distribute knowledge through open communication media and educational systems.

It is difficult to define and attain economic mixes (1) of centralized and decentralized ownership of power and control, and (2) the stability and flexibility in patterns of power ownership. Yet attaining such mixes is crucial to effective, rational decision-making.

Responsibility Bearing

Responsibility for decisions is borne by decision-makers and affected persons. Responsibility for the action actually executed is different than for the *intended action.* The executive may be held responsible for failure to do what the decision-making unit decided should be done.

The consequences of actions need to be monitored both positivistically and normatively for use in defining and solving the problems which emerge as the affairs of an entity are managed adaptively through time. Two important feedback loops for public decision-makers are political processes and the public press (if they are free to originate messages). Though the price system of a market-controlled economy is primarily a feedback mechanism among decentralized decision-makers, it is an extremely important source of normative information to public decision-makers; deprivation of public administrators of this source of information creates a need for information on unconsumed stocks in government warehouses, underemployment, rates of consumption, unfilled ration stamps, unmet quotas, etc. Where power is absolute, political monitoring may be neglected while the press is converted to governmental information systems to "feed forward" regulations and orders; to the neglect of the feedback function.[55]

PART II

Contributions Economists Can Make

With the above summary, we are now in position to consider the contributions economists can make – (1) as participants in decision-making, (2) as doers of subject-matter research, and (3) as doers of disciplinary research. All three are important and none are to be denigrated by me.

As Participants in Decision-Making – When an economist helps solve problems, he operates in a far different arena than when doing subject-matter or disciplinary research. The object is to help prescribe a solution. Interaction is required with decision-makers and affected persons possessing market, political, and/or military power.

A first and continuing task in problem-solving is to define the policy problem under consideration. Problem definitions determine the multidisciplinary mix required to understand the domain of the problem. Very few practical problems can be handled by a single discipline such as economics.

One of the important contributions which economists can make is their understanding of how markets operate and of the important role which price systems play in transmitting information among affected persons. Economists should also be able to (1) contribute an understanding of how market mechanisms can creat undesirable distributions of resource ownership and (2) help predict the consequences of changing ownership patterns.

In participating in problem-solving activities, economists represent but one of a number of disciplines. They are expected to contribute disciplinary excellence: theory, empirical knowledge and command over quantitative techniques for handling empirical information and for processing it into prescriptions. An economist will be looked to particularly for assistance in reaching maximizing (prescriptive) decisions. He will also be looked to for assistance in modeling the maximizing behavior of the producers, consumers, resource owners and public officials in the economy. In doing these things, he will be expected to join multidisciplinary teams and to recognize that the need for administration of problem-solving research supersedes the interest of particular disciplines, including economics.[56] If the problem-solving effort cannot be administered, the economist is well advised not to participate in it. And, if the economist is not willing to accept administration but wants, instead, to do his "own thing" as an economist, he should not join a problem-solving effort.

Great philosophic flexibility is required of economists participating in problem-solving exercises. It is reasonable to expect them to develop normative as well as positive descriptive information[57] and to be in command of economic logic for processing them into prescriptions. The normative information will be non-monetary as well as monetary.

Also, economists should be sensitive to the information obtainable interactively from decision-makers, executors of decisions, and affected people. Also they must be aware of the importance of property and power distributions as they affect decision and execution.

Great flexibility is required with respect to techniques. Decisions are reached on the basis of multidisciplinary conceptualizations of problematic domains. Such conceptualizations are difficult to verify and validate. The credibility of a prescription is determined essentially by the four tests of coherence, correspondence, clarity and workability. Economists should be prepared to use all four in problem-solving exercises.

Economists have had much experience in (1) developing models of the *structure* and the *conduct* of both private and public systems and (2) projecting the consequences of alternative actions in terms of various criterion or *performance* variables. Multidisciplinary projections have been relied on by public decision-makers in the past and will continue to be in the future; however, future projections can be far superior as the electronic computer has reduced costs. Common sense, flexible, multidisciplinary projections for problematic domains can now be made which would have been prohibitively expensive just a few years ago. One of the principle contributions which economists have to make to rational public decision-making is to bring computerized projections into much fuller use in assisting public decision-making. Such models include human components or are used interactively and adaptively with people – administrators and affected people.

Economists, in my view, have been slow in exploiting the general, systems-science simulation approach to making projections because (1) highly-trained economists are often unwilling to leave the narrow confines of economics to cooperate with other disciplines in using the approach, (2) of unduly specialized philosophic orientations, (3) of addiction to specialized quantitative techniques and (4) of cultural lag with respect to the general, systems-science simulation approach among older economists. Many older economists, having been burned in the past by the poor results from linear programming, econometric models, and other specialized quantitative techniques, now often react adversely to all quantitative models – even models which attempt to obtain enough generality in making projections to overcome the undue specialization which burned them in their youth and now blinds them in their maturity!

Michel Petit, Kim Dong Hi and Lars Folkeson will expand our thinking on modeling further tomorrow.

Subject-Matter Research – Such research is designed to bring together information on a specific subject which is relevant for solving a set of problems involving *that kind of information.* While not focused on a particular problem, subject-matter research is important for public decision-making. Examples include research on such subjects as energy, poverty, international trade, land-tenure, food, employment generation, environmental quality, etc. In doing such research, economists should recognize that they are working on a subject not a problem – on one kind of information needed to solve a specific large set of problems.[58]

Subject-matter research is relevant to sets of problems and, like research on a specific problem, is multidisciplinary. One of the first things to be done in mounting a subject-matter research effort is to define the *set of problems* for which a specific kind of information is being accumulated. Although

subject-matter research has *some* of the characteristics of problem-solving research, the immediate objective is not prescriptive.

Economists are expected to (1) contribute disciplinary excellence to subject-matter research in the forms of economic theories, empirical information, and quantitative techniques and (2) cooperate with other disciplines in getting the necessary information together. However, the amount of administration required and which has to be accepted by economists is less than for problem-solving research.

Subject-matter researchers deal with data collection, storage and retrieval. They also obtain guidance from models and logical structures for, as Bonnen and others point out, it is theory which converts data into knowledge.[59]

For both the data and models, it is necessary for subject-matter researchers to recognize that:

(1) The subject involves a *set* of problems not a *single* problem, but
(2) That each problem in the set has a unique domain with which decision-makers using the subject-matter research will have to deal.
(3) The "practical out" is to:
   (A) develop models and data which will be useful, if not fully adequate, for each problem in the set of problems involved, and
   (B) which are componentized so that components can be added and subtracted to fit the specific domains of specific problems in the set of problems under consideration; and
   (C) which are also componetized so that they can be taken apart and recombined in configurations by decision-makers and problem-solving researchers to fit the specific domain of a specific problem being solved.

Disciplinary Research – Because many future problems are unknown, it is extremely difficult to classify disciplinary research as relevant and irrelevant. It can be classified as: (1) that known to be relevant and (2) that not known to be relevant. The concern here is with disciplinary research of known relevance. Often practical problems go unsolved because the necessary disciplinary research has not been none.

Doing disciplinary is much different than doing problem-solving and subject-matter research. Disciplinary research of economists, consists of attempts to improve the theories, quantitative techniques and data of economics. At times, problem-solving and subject-matter research require relevant disciplinary research as the theories, techniques and data of economics are often inadquate.

The contributions needed are both large and small in both statics and in dynamics, with respect to the theoretical, the descriptive and with respect to quantitative techniques.

The faddish word "paradigm" was discussed earlier in this paper. Some economists, particularly those concerned with non-market changes and dynamics, argue that what they call neoclassical paradigm needs to be abandoned and completely replaced by some other paradigm which addresses itself to a *new* problem. I doubt this. I believe, instead, that our paradigmatic

changes should be mainly those which we encounter in going from one problem to the next. In doing this, we will find much from the neoclassical tradition, Keynesianism, modern welfare economics and various extant forms of dynamics to be useful. I believe we will evolve as a continually relevant discipline which helps solve each generation's problems. Our job as disciplinarians will be to extend and add to what we have so as to be able to model the economic aspects of the domain of the problems at hand.

In discussing needed disciplinary research in 1971, I wrote as follows:[60]

> The deficiencies . . . provide specific priorities for our disciplinary research. Some of the priority areas are: Investment–disinvestment theory; stock–flow conversion theory; user–cost concepts; benefit–cost concepts; the relationships between effective demand and production; the generation, saving, and investment of farm-produced capital; dynamic managerial theory; and premaximization concepts to use in establishing the necessary conditions for applying maximization theories. Other important deficiencies involve theories for dealing with the formation of and trade-offs among individual and group values. These and other subjects all need disciplinary research to make our problem-solving efforts and investigations more effective . . .
>
> While we still have difficulties in estimating the parameters of economic functions and sets of simultaneous equations, I believe that we have over-emphasized improving such estimates at the expense of failing to improve other more needed estimates and sources of information. In the last 20 years we have also made great efforts to improve maximization computations, particularly modifications and refinements of linear programming. I believe that this area of work has also been over-emphasized relative to the use of projections, simulations, and premaximization computations. Our quantitative techniques for dealing with normative questions . . . are inadequate and in need of much more disciplinary research.

What I wrote in 1971 still holds but I now add a more specific stress on dynamic economics. We saw earlier the need to understand the economics of performing the six problem-solving processes. A needed reorientation of risk and uncertainty theory towards prescriptive knowledge has scarcely started. The relationships among decision-making and execution, on one hand, and the stability and distribution of the ownership of power, on the other, are poorly understood although wars are fought about them. The essentially normative nature of production (that which is valued) and waste (that which is not valued or is valued negatively) needs to be researched. The dependency of the meanings of aggregate output and efficiency on the distribution of the ownership of rights and privileges needs to be better understood. Output and equity are not independent variables – the meaning of one depends on the other and the trade-offs between them are not simple indifference lines on simple, static, social utility functions. We require better techniques for working with nonmonetary values if we are to research (1) the non-pareto-better consequences of market activity in the presence of

imperfect knowledge and transfer costs and (2) the economics of non-pareto-better, nonmarket adjustments in technology, institutions and people.

We also need disciplinary research on the economics of such information systems as market price mechanisms, political processes, the press, educational institutions including agricultural extension as well as public data and information systems.[61]

If disciplinary research is to be of known relevance then disciplinary researchers must be in touch with the problems for which it is relevant. Such contact is probably more important than administrative services insofar as disciplinary research is concerned. Cooperating with other disciplines and flexibility with respect to knowledge from other disciplines are much less important for disciplinary than for problem-solving and subject-matter research. Within the disciplines of economics, one can concentrate upon the positive, normative or pragmatic and hence need not be particularly flexible philosophically. However, if one wants to cover all contributions which economics can make to either subject-matter or problem-solving research, philosophical flexibility is required.

NOTES

[1] Dunn, E. S. (1970) *Economic and Social Development – a Process of Social Learning,* The Johns Hopkins Press, Baltimore; Mack, Ruth, *Planning on Uncertainty,* John Wiley, N.Y.; also, Dunn, E. S. (1974) *Social Information Processing and Statistical Systems – Change and Reform,* Wiley-Interscience, New York; and Arrow, Kenneth, *Social Choice and Individual Values,* John Wiley and Sons, Inc., and Arrow, Kenneth J. (1974) Nobel Laureate, *The Limits of Organization,* W. W. Norton & Co., New York.

[2] I will draw, in this paper, on the literature noted in these notes and on personal experiences in (1) the Interstate Managerial Study (IMS), a micro-level empirical study in seven U.S. states of the managerial activity of 1075 mid-west farmers, (2) administering problem-solving research at the Economic Development Institute, the University of Nigeria, and the Consortium for Study of Nigerian Rural Development, Michigan State University's Agency for International Development studies of agricultural sector, systems-science, simulation models, including two Korean projects which utilized such models, (3) consulting with foreign and domestic decision-making agencies in government and with individual farmers, and (4) researching problems of foreign and domestic decision-making agencies both public and private. These experiences are reported in the following: Johnson, Glenn L., Halter, A. N., Jensen, H. R., and Thomas, D. W., (eds.) (1961) *A Study of Managerial Processes of Midwestern Farmers,* Iowa State Univ. Press Ames. Also, Johnson, Glenn L., and Haver, C. B., (1953) *Decision Making Principles in Farm Management,* Kentucky Agric. Exp. Sta., Bul. 593. Johnson, Glenn L., Scoville, O. J., Dike, G. K., and Eicher, C. K. (1969) *Strategies and Recommendations for Nigerian Rural Development, 1969/1985 (CSNRD 33),* Consortium for the Study of Nigerian Rural Development with the support of USAID, Cont. AID/Afr. 264, MSU, E. Lansing, Mich. Also, Manetsch, T. J. *et al.* (1971) *A Generalized Simulation Approach to Agricultural Sector Analysis With Special Reference to Nigeria,* produced by the MSU Simulation Team under USAID, Cont. AID/csd-1557, MSU, E. Lansing, Mich. Rossmiller, G. E. *et al.* (1972) *Korean Agricultural Sector Analysis and Recommended Development Strategies, 1971–1985,* Korean Agric. Sector Study Team with support from USAID, Cont. AID/csd/2975, Ministry of Agric. and Forestry, Seoul, Korea and Dept. of Agric. Econ., MSU, E. Lansing, Mich. Johnson, Glenn L. (1952) *Burley Tobacco Control Programs,* Kentucky Agric. Experiment Station, Bul. 580, Feb. Also Johnson, Glenn L. and Zerby, Lewis K., (1973) *What Economists Do About Values – Case Studies of Their Answers to Questions They Don't Dare Ask,* Dept. of Ag. Econ., MSU, E. Lansing, Mich. Ch. II, 'The Problems of Improving U.S. Economic and Military Aid to Thailand',

Ch. III, 'Development Problems in Western Kentucky', Ch. V, 'Establishing a National Recreation Area in Mich.', Ch. IX, 'Research on Nigerian Rural Development', Ch. X, 'Selecting a Survey Sample Size'.

[3]Johnson, G. L. and Zerby, L. J., *Ibid.*, Chapters I and XI.

[4]This conception of managerial (decision-making) units makes it unnecessary to stretch our concepts of reality to the point of making management an input in, for instance, dairy production capable of generating marginal physical and value products instead of regarding it more realistically as deciding how much hay and grain a cow will get to eat to convert in marginal physical outputs of milk. In many analyses, management is inappropriately treated as a factor of production or "shifter" of production, supply and demand functions. Such "inputs", or shifters, are in effect *decisions*, not inputs, as to how factors of production and consumer goods (among other things) are used. See *The Management Input in Agriculture*, Agric. Policy Inst., Southern Farm Management Research Comm., Farm Foundation, April, 1963, Ch. I by Johnson, Glenn L., 'Methodology for the Managerial Input', and Eicher, C. and Witt, L. (1964) *Agriculture in Economic Development*, McGraw-Hill, New York, Ch. 6, 'A Note on Conventional Inputs and Nonconventional Production Functions'.

[5]Johnson, G. L. *et al.*, *Managerial Processes of Midwestern Farmers, op. cit.*, and *Research on Problems of Agrarian Change*, (tentative title) European Review of Agricultural Economics, The Hague. Authored by the TransAtlantic Committe on Agricultural Change with support from the Rockefeller Foundation, cooperating authors: Day, R. H., Heidhues, T., Petit, M., Renborg, U., and Johnson, G. L.

[6]See Friedman, Milton (1943) *Essays in Positive Economics*, University of Chicago Press, Chicago, for a presentation that fails to recognize the normative nature of prices.

[7]Definitions of positivism and conditional normativism are to be found in Johnson and Zerby, *op. cit.*, pp. 15f and 19f.

[8]Johnson, Glenn L., *et al.*, *op cit.*

[9]See Dunn, E. S., *Economic and Social Development, op. cit.*, Chapter V for an explanation of the neglect of the normative by economists and an exposition of why we must deal with the normative in decision-making.

[10]*Research on Problems of Agrarian Change* (tentative title), *op. cit.*, Ch. 5 by Johnson, G. L., 'Philosophic Foundations: Problems, Knowledge and Solutions', and Ch. 6 by Day, R. H., 'Towards an Adaptive Economic Theory', (forthcoming). Also see M. B. Mbithi's excellent paper on the human factor in farm management presented at this conference.

[11]Johnson, D. Gale (1945) *Forward Prices for Agriculture*, University of Chicago Press, Chicago.

[12]Katona, George (1951) *Psychological Analysis of Economic Behavior*, McGraw-Hill Book Co., Inc.

[13]Kuhn, Thomas S. (1970) *The Structure of Scientific Revolutions*, Vol. II, No. 2 of Foundations of the Unity of Science, University of Chicago Press, Chicago (enlarged edition).

[14]Johnson, *et al.* (1961) *Managerial Processes of Midwestern Farmers*, Iowa State Univ. Press, Ames, *op. cit.*, p. 26.

[15]Boulding, Kenneth (1956) *The Image*, The University of Michigan Press, Ann Abor, pp. 173. This quotation we note, as an aside, is at variance with Robbins, Lionel (1949) *The Nature and significance of Economic Science*, MacMillan and Co., Ltd, London, and Friedman, *op. cit.*

[16]See *Research on Problems of Agrarian Change, op. cit.*, Chapter V for a diagram including the prescriptive.

[17]Johnson, G. L. (1961) *Managerial Processes of Midwestern Farmers*, Iowa State Univ. Press, Ames, *op. cit.*, pp. 88ff and Ch. 7 by Halter, A., 'Utility of Gains and Losses'.

[18]Hicks, J. R. (1939) *Value and Capital*, Oxford University Press, London; Von Neumann, John and Oskar Morgenstern (1974) *Theory of Games and Economic Behavior*, Princeton University Press, Princeton, N.J. Halter, Albert N. and Gerald W. Dean (1971) *Decisions Under Uncertainty*, South-Western Publishing Co., Cincinnati,

Ohio; Friedman, M. and Savage, L J. (1948) 'The Utility Analysis of Choices Involving Risks', *Journal of Political Economy,* LVI, pp. 279–304.

[19]Heady, E. D. (1952) *Economics of Agricultural Production and Resource Use,* Prentice Hall, pp. 476ff.

[20]Nerlove, Marc (1958) *The Dynamics of Supply: Estimation of Farmers' Response to Price*, Johns Hopkins Press, Baltimore. Also see review by Johnson, Glenn L. (1960) in *Agricultural Economics Research,* USDA, January, Vol. XII, No. 1, pp. 25–28.

[21]Johnson, Glenn L. and Quance, C. Leroy (1972) *The Overproduction Trap in U.S. Agriculture,* Johns Hopkins University Press, Baltimore, Ch. 5 by Lerohl, M.L. 'Expected Product Prices', Also Petit, M. J. (1964) 'Econometric Analysis of the Feed-Grain Livestock Economy', unpublished Ph.D. thesis, MSU.

[22]See Dunn, *Economic and Social Development op. cit.,* Chapter V for a discussion of how widespread this mistake is among economists and in the scientific community, in general.

[23]Heady, E. O., *et al.,* (eds.) (1958) *Agricultural Adjustment Problems in A Growing Economy,* Iowa State College Press, Ames, Iowa, Ch. 18 by Kenneth H. Parsons, 'The Value Problem in Agricultural Policy'.

[24]Georgescu-Roegen, Nicholas (1971) *The Entropy Law and the Economic Process,* Harvard University Press, Cambridge, Massachusetts.

[25]Johnson and Zerby, *op. cit.*

[26]Manetch, *et al., op cit.;* Rosmiller, *et al., op. cit.*

[27]Myrdal, Gunnar (1944) *The American Dilemma* Harper Bros., New York, appendix II.

[28]Heady, *Agricultural Problems in A Growing Economy, op cit.,*

[29]Moore, G. E. (1956) *Principia Ethica,* Cambridge at the University Press, Cambridge, England.

[30]Carnap, Rudolph (1953) 'Formal and Factual Science' in Feigl, Herbert and Brodbeck, May, *Readings in the Philosophy of Science,* Appleton-Century-Crofts, Inc., New York, pp. 123–8.

[31]In response to a question by a discussion opener, Prof. Zohlnhoufer, a "strictly ordered preference function" is not assumed; instead, normative as well as positive learning is recognized as taking place to contribute to the normative data bank.

[32]Bonnen, James T. (1975) 'Improving Information on Agriculture and Rural Life', *AJAE,* Vol. 57, No. 5, December.

[33]Dunn, Jr., Edgar S., in *Social Information Processing and Statistical Systems, op. cit.*

[34]See Lewis, C. I. (1955) *The Ground and Nature of the Right,* Columbia University Press, New York, for a discussion of *right* and *wrong* goals, targets and actions as distinct from values. At the request of a discussant, Professor Zohlnhoufer, I add that *normative* concepts deal with the goodness and badnesses, *per se,* of conditions, situations and things. *Positive* concepts with the characteristics of conditions, situations and things other than their goodness or badness. The prescriptive deals with concepts about "what ought to be done" which depends functionally on both positive and normative concepts, the functional relationship between the two being a decision rule or strategy.

[35]Knight, Frank H. (1946) *Risk Uncertainty and Profit,* Houghton Mifflin Co., Boston. At the 1975 meetings of the American Agricultural Economics Association, a number of papers on risk and uncertainty did not up-date Knight's risk and uncertainty concepts. The paper by Richardson, *et at.,* at this conference ignores both the obsolete and modern distinctions and hence the economics of deciding how much information to acquire (learn).

[36]Hart, A. G. (1946) 'Risk, Uncertainty and the Unprofitability of Compounding Probabilities', *Readings in the Theory of Income Distribution,* The Blakiston Co., Philadelphia.

[37]Wald, Abram (1947) *Sequential Analysis,* John Wiley and Sons, New York.

[38]Acceptable positive truth is, we see, relative to the values sought and avoided in solving a particular problem.

[39]Johnson, G. L., *et al.* (1961) *Managerial Processes of Midwestern Farmers,* Iowa State Univ. Press, Ames, *op. cit.,* Ch. 3 by Johnson, G. L. and Lard, C. F., 'Knowledge Situations'.

[40] Hubbard, J. W. and Chastain, E. D., experienced difficulties with the classifications some of which may be related to the discussion in the next section. See Hubbard, J. S. (1960) 'An Appraisal of the Farmer Knowledge Situations Investigated by the Interstate Managerial Survey', *JFE,* Vol. XLII, May, p. 335f, and Chastain, E. D. (1956) 'An Empirical Study of the Decision-Making Process in Farm Management', unpublished Ph.D. thesis, Purdue University, Lafayette, Indiana.

[41] Johnson, Glenn L. (1957) 'Production Economics and the Field of Farm Management', *JFE,* Vol. 39, May, pp. 441f, and 'Stress on Production Economics', *Australian Journal of Agricultural Economics,* Vol. 7, No. 1, June 1963, pp. 12–26.

[42] I refer here to the highly productive work on these subjects at the University of Chicago and elsewhere in the last decade or so.

[43] Dunn, Jr., Edgar S., *Economic and Social Development, op. cit.*

[44] Johnson, G. L., *et al.* (1961) *Managerial Processes of Midwestern Farmers,* Iowa State Univ. Press, Ames, *op. cit.,* 'Implications of the IMS for Study of Responses to Price', Chapter 10; Edwards, Clark, 'Resource Fixity and Farm Organization', *JFE,* Nov., 1959; and Johnson, Glen L. and Quance, C. L., *The Overproduction Trap in U.S. Agriculture,* Johns Hopkins Univ. Press, *op. cit.* In addition, the reader's attention is also called to the unfortunate review of *The Overproduction Trap* by Dale Hoover, *AJAE,* Vol. 55, May 1973, pp. 354–5 which failed to detect the difference between the analysis in the appendix and earlier work by Cassells. The appendix indicates that supply responses would be expected to be symmetrically asymmetrical with respect to increases and decreases in product prices where Cassells concluded that they would be asymmetrical. The appendix indicates responses to price increases should not be expected to be the reverse of responses to price decreases with the same being true, symmetrically, for responses to price increases after price decreases. When farmers have been expanding investments in response to favorable prices they do not disinvest in response to small decreases in product prices. Similarly, when farmers have been contracting production as a result of decreases in produce prices they should not be expected to immediately expand investments when they experience small increases in prices. The mathematical appendix explains responses far different than postulated by Cassells. At a recent Agricultural Development Council Conference on Risk and Uncertainty held at the Centro Internationale Mejoriemente Mais y Trigo, March 9–13, 1976 papers and discussions dealing with market distortion due to risk and uncertainty were presented by Michael Lipton, P. B. S. Hazell and P. L. Scandizzo, David M. G. Newbery and Joesph Stiglitz. These papers were ground-breaking in general economics, if not in agricultural economics, for recognizing the distortion effects of risk and uncertainty; however, they failed to cover the market distortions for which *both* imperfect knowledge and acquisition cost/salvage price differentials are necessary but individually insufficient. These are covered in *The Overproduction Trap.*

[45] For a simple discussion of alternative decision rules see Clark and Schkade, *op. cit.,* pp. 415f. What I refer to as decision rules they call criteria for making decisions under uncertainty. Jock Anderson's paper presented at the ADC Conference on Risk and Uncertainty, March 9–13, 1976 in the CYMMIT, *op. cit.,* is a particularly good summary of alternative decision rules.

[46] Knight, Frank H., *Risk, Uncertainty and Profit,* Houghton Mifflin Co., Boston.

[47] Alternatively 'pooled samples'.

[48] Because mutually benefical decisions take place in the markets of decentralized economies but are centralized in centralized economies.

[49] We must stress the people content of the total model as anti-modelers often mistakenly assume that models exclude people.

[50] Manetsch, Thomas, *et al., Generalized Simulation Approach to Agricultural Sector Analysis, op. cit.* and Rossmiller, G. E., *et al., Korean Agricultural Sector Analysis and Recommended Development Strategies, 1971–1985, op. cit.*

[51] Piero Mini in a recent book on philosophy and economics distinguishes between a mechanical Descartian economics based on thought and logic and an empirical or synthetic economics based on experience with matter and sensation. The GSSSA under consideration here utilizes interactions between man and computer components and

both positive and normative primitives to map analytic into synthetic systems. As such it crosses the bridge between the two kinds of economics of concern to Mini. These GSSSA models and decision models are complex. Mini, Perio V. (1974) *Philosophy and Economics,* The Univ. Presses of Florida, Gainesville, Florida.

[52]A special case of added costs equal to added returns because outside forces either make added costs infinite or added returns zero.

[53]A paper by Jock Anderson at a recent Agricultural Development Council Conference at CIMMYT concentrated on decision-making without taking these crucial interrelationships into account.

[54]Completely ordered preference functions are not only not assumed, they are typically *uneconomic* to develop!

[55]Georgescu-Roegen, Nicholas, *op. cit.,* pp. 306–7.

[56]In this connection see my Fellows Address entitled 'The Quest for Relevance in Agricultural Economics', *AJAE,* Vol. 53, No. 5, Dec. 1971, pp. 728–39, Fellows Address, Summer Meetings, 1971.

[57]*Ibid.*

[58]In earlier work, I unwisely lumped problem-solving and subject-matter research together under the term 'issue-oriented, problem-solving work'. See Johnson, *The Quest for Relevance, op. cit.*

[59]Bonnen, James T., *op. cit.*

[60]Johnson, Glenn, L. (1972) 'Alternatives to the Neoclassical Theory of the Firm (NTF)', *AJAE,* Vol. 54, No. 2, May, pp. 295–303.

[61]In effect I extend Bonnen's plea to include information systems other than governmental statistical systems. See Bonnen, *op. cit.*