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THE ROLES OF THE ECONOMIST IN STUDYING PROBLEMS INVOLVING ENERGY AND FOOD

Glenn L. Johnson*

Economists often feel neglected in connection with studies of problems involving food and energy when they find others failing to see certain rudimentary economic relationships at all and of misconceiving of others.

Is Economics Neglected?

For instance, they find technical agricultural scientists courting congressional appropriations by promising or implying that more money spent on technical agricultural research will not only increase food production but will keep food prices from rising despite world wide inflation and financial mismanagement,[1/] a promise which astounds and dismays persons trained in monetary/fiscal economics and international trade. Economists find others computing questionable net energy balances by assigning equal values to all calories whether in fertilizer, gasoline, cow manure, hay, wheat, blue cheese or filet mignon.[2/] Still others preach about international equality in access to the world's food and energy resources without attention to what this means in a world of political, military and economic processes and power.

[1/] An early version of a forthcoming but still privileged document by the Committee on Agricultural Productivity and Efficiency of the National Science Foundation.

[2/] Pimentel, D., et al., "Food Production and the Energy Crisis," Science, 182:443-449, November 2, 1973

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In still other instances economists are driven up walls by persons who do not distinquish between (1) supply functions and production, or (2) demand functions and consumption. "Food gaps" are computed without taking into account the role of changing prices in equating production with consumption, FAO being an important offender in this instance. Perhaps the greatest source of uneasiness on the part of economists is the dogma which is peddled by crusaders whether the crusaders are the energy conservationists, ecologists, or consumerists.

Much of the dogma perpetuated with respect to food and energy elevates a particular good to the status of the ultimate good--a common denominator--the summon bonnum--in terms of which all other values are expressed. Energy, despite Pimentel's computations, does not seem to be the common denominator of all human values.[3] Even food, important as it is in maintaining life, is not a common denominator of human values. Economists recognize index number problems when they see them and become very uneasy in their presence. Fortunately, some respected bio-physical scientists are now speaking out against the damages of pseudo common denominators.[4]

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[3] Ibid.

[4] Science, 15 March 1974, Vol. 183, No. 4129, p. 1041, "That we must actively concern ourselves with the social and moral consequences of science, I fully recognize. But to discharge this duty with full responsibility requires avoiding the two favorite pitfalls of facile humanists; basing one's entire assessment on a single value and assuming empirical facts rather than gathering and analyzing data relevant to the assessment at hand." The thing wrong with this quote is that physical scientists are greater offenders than humanists! See Pimentel Ibid., and associated literature.

There is More to It than Merely Introducing Economics

If the difficulty were simply one of the neglect of economics, it would be relatively easily handled. All we would have to do would be to use our numbers, influence, and prestige to insure that economics gets a chance to play its proper role; however, as I see it, the difficulties are mainly with us. It appears that we are neglected not out of malice but because there is a real credibility gap between us and both public and private decision makers.

This lack of credibility is with respect to the contribution which economists and economics have to make to the solutions of problems involving energy and food. Thus, it behooves us to examine our shortcomings as economists before complaining too much about the neglect of economics by physical scientists, public and private decision makers, and yes, even the crusaders. We cannot complain about harlot crusaders until we put our own home in order. I believe we will continue to deserve neglect until we resolve certain difficulties to be considered below.

Economists are Probably Responsible for Their Neglect

One difficulty involves the confused roles which we elect to play as economists. Also, we have difficulties with the philosophies which guide us into our roles and condition our theoretical and quantitative work. Other related difficulties involve inadequacies of our quantitative techniques and theories.

Different Roles for Economists to Play with Respect to Energy and Food Problems:[5/] --There are essentially three roles to be played with

[5/] Currently, personnel associated with the agricultural information project of the new Congressional Office of Technology Assessment are experiencing difficulty in defining their role. The author is a member of this group.

respect to problems involving energy and food by economics and/or economists; they are those of (1) a relevant discipline or of relevant disciplinarians, (2) a subject matter specialist the subject being energy or food and (3) a problem solving or problem solver, either in total or contributory.

There is a discipline of economics. That discipline exists in universities and like all academic disciplines, its roles include those of (1) improving itself through development of techniques, theory, and descriptive information, and (2) providing for intergenerational transfer of its knowledge. Academic disciplines are not necessarily oriented towards problem solving, at least not problems beyond those encountered by the discipline itself in teaching its subject matter and in improving its techniques, theories, and descriptive knowledge.

With respect to the problems involving energy and food which are now before society, a discipline such as economics can be relevant, of unknown relevance, or irrelevant. Despite the possibilities of irrelevance and unknown relevance, it is clear that there are techniques, theories and descriptive information to be developed by economists which are necessary in order to solve the problems involving energy and food problems which are before society. When we seek a conscious disciplinary role in solving problems involving food and energy, we must play it in the area of known disciplinary relevance. We create credibility gaps for ourselves when we do irrelevant disciplinary work and pretend it is problem solving. Also, we create credibility gaps when we pretend or imply the relevant disciplinary work is problem solving work; it may help solve problems but reaching solutions, as we will see later, typically involves more than economics.

Economists can also play the role of subject matter specialists and specialize in the subjects of energy and/or food. Though such a role is specialized, it is automatically broader than that of being an economist because knowledge about energy and food is produced by many disciplines other than economics including the humanities, bio-physical disciplines dealing with technology, and the various other social sciences. Some of the work of the Stanford Food Research Insititute is illustrative. We must point out however that subject matter specialists are not necessarily problem solvers. They can be concerned with energy or food as subjects whether or not there are problems involving energy and food. Such subject matter specialists are more like disciplinarians than problem solvers in the sense that their work can be relevant, irrelevant or of unknown relevance to the solution of problems involving food and energy. The specialist concerned only with food and/or energy as subjects is not typically capable of solving problems involving food or energy because such problems usually involve so much more than food and energy. This, however, does not preclude food and energy specialists from doing much work relevant to the solution of problems involving food and energy. In fact, in the subject matter role, an economist can probably make a greater contribution to solving problems involving food and energy than in the role of disciplinarian precisely because the subject matter role permits him to be more than just an economist. Here again the danger of creating credibility gaps exists; we cannot imply that information about food and energy is sufficient to solve the many of the complex problems of the real world which involve food and energy however necessary it is.

Another role which economists can play is that of problem solvers. When this role is discussed, we have to be rather careful about the meaning of the word problem. We can define a problem as existing when a public or private decision making person or agency with power to act finds that a situation is less good or more bad than it would have had to be, given the constraints upon the decision making unit.

When most so called energy and food problems are looked at in the light of this definition, we do not find the energy problem or the food problem; instead, we find a large number of specific problems before public and private decision makers which involve energy and food but which are not confined, typically, to just energy and/or just food. Solving such problems requires much more than the discipline of economics and much more than the contributions of persons specializing in the subjects of energy and/or food.

Problems are defined and solved in normative as well as positive terms; this in turn opens up a Pandora's box of philosophic questions about the possibilities of being both "scientist" and "problem solver," etc. Regardless of how such questions are answered, persons playing the role of problem solvers must deal with values, non-monetary as well as monetary. And, economists, having written much of the classical and modern literature on philosophic value theory, are in as strong a position as any group of disciplinarians to handle values in playing the problem solving role.

The problem solving role can be played partially as well as totally but we should not imply that partial work solves problems in and of itself. In playing the problem solving role on a partial basis economists can do relevant disciplinary work and subject matter work thereby avoiding some of the multidisciplinary demands of working on the total package of knowledge required to solve a given problem. Much of the credibility gap

which we have with public and private decision makers arises, I believe, because we persist in treating irrelevant disciplinary and relevant disciplinary work as problem solving. We encounter a similar lack of credibility with our bio-physical science colleagues. Somehow, both decision makers and our colleagues in other disciplines recognize that there is more to solving problems involving food and energy than applying the maximizing principles of economics. I have sensed and been told this while serving as a member of a National Academy of Science Committee on Agricultural Research Priorities for Africa,[6/] in working on a prefeasibility study for a Korean Agricultural Research Project[7/] and in reviewing various documents produced for Research Applied to National Needs (RANN) and the Committee on Agricultural Productivity and Efficiency (CAPE) both of the National Science Foundation (NSF).[8/]

Inadequacies with our Philosophies:--Time does not permit an adequate review of the philosophies which guide economists and which

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[6/] McKelvey, John J., et al., The African Agricultural Research Capability Study. In the process of being published by NAS.

[7/] Investment Priorities in the Korean Agricultural Sector, Agricultural Research Institute, Seoul, Korea and Department of Agricultural Economics, Michigan State University, East Lansing, Michigan. 1972. See part IV entitled "An Investment in Support of Agricultural Research" by Glenn L. Johnson and Sylvan Wittwer.

[8/] I refer here to three privileged documents currently in NSF hands which may be published:
"Research to Assure Food During the Twentieth Century." Paul E. Wagonner, Director, Conn. Agr. Exp. Station.
"Research Recommendations for Increasing Food, Feed, and Fiber Crop Production in the USA" by Sylvan Wittwer, Director, Michigan Agricultural Experiment Station.
Report of the Committee on Agricultural Productive Efficiency (CAPE) of N.S.F.

partially determine the roles they elect to play.[9/] As many of us have not studied our philosophic underpinnings explicitly, we are often unaware of the pervasive influence of our philosophic orientations. It often comes as a surprise to find that the roles we play are determined by our philosophies through the teachers, professors and readings important in our personal life histories.

An important philosophy which conditions our roles is that of positivism.[10/] Positivism holds that the only descriptive knowledge to be gained by scientific investigation is from experience and observation. It further holds that values are emotive, unobservable and not experienced; hence, the "positive" knowledge of positivists is "non-normative i.e., that kind of descriptive knowledge which does not deal with the goodness and badness of conditions, situations and things. This implies that a through-going positivist is not likely to play the role of problem solver. If he plays that role, he is likely to envision it as being beyond his activities as a scientist because defining and recognizing solutions of problems requires the use of normative concepts not amenable in his view to the tests of experience and observation as part of the "real factual" world. Thus, the role selected by a positivistic economist is likely to be that of describing the non-normative

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[9/] Johnson, Glenn L. and Lewis K. Zerby, What Economists Do About Values, Department of Agricultural Economics, Center for Rural Manpower and Public Affairs, Michigan State University, East Lansing, Michigan, 1972. Chapters I and XI.

[10/] Some colleagues of the writer feel that discussions of philosophy are mainly semantic. We do have greater difficulty with the meanings of philosophic words. For a discussion of the difficulties of economists, the reader is also referred to Fritz Machlup, "Positive and Normative Economics; An Analysis of the Ideas" in Robert Heilbroner, Economic Means and Social Ends.

aspects of food and energy phenomena leaving to non-scientific (as they view science) personnel the task of using "non-scientific" processes to define and solve problems.

Pragmatists on the other hand concentrate upon problems and the problem solving role. Pragmatism has been important historically in agricultural economics, particularly among institutionalist. Currently pragmatism has received substantial support from both Boulding[11/] and Georgescu-Roegen in his book entitled, The Entropy Law and the Economic Process.[12/] Pragmatists, in concentrating upon problems and problem solutions, envision positivistic and normative concepts as being mutually interdependent in the context of the particular problem in which the concepts are important. In judging the "truth" of a concept, the pragmatist relies substantially on the test of whether the concept "works" in solving the particular problems under investigation. Thus, to the pragmatist, truth, itself, is problem-oriented and the truth of a positive concepts depends on concepts of values and vice versa.

Some non-pragmatic economists desiring to work on problems of decision makers have followed the positivistic lead to the extent of avoiding investigation of the normative by assuming but not investigating concepts of the "goods" to be sought and the "bads" to be avoided; this permits them to define a problem and to concentrate their efforts upon the

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11/ Boulding, Kenneth, "A New Look at Institutionalism," presented at the December 1956 meeting of the American Economics Association, Cleveland, Ohio.

12/ Georgescu-Roegen, Nicholas, The Entropy Law and the Economic Process. (Cambridge, Mass.: Harvard University Press, 1971). Four Reviews appeared in Journal of Economic Issues, Vol. VII, No. 3, September 1973. Reviews prepared by: Richard Schlegel, Department of Physics, Michigan State University; Ralph W. Pfouts, Department of Economics, University of North Carolina, Chapel Hill; Werner Hochwald, Department of Economics, Washington University; and Glenn L. Johnson, Department of Agricultural Economics, Michigan State University.

acquisition of the positivistic information required to solve that problem. I have dubbed such economists "conditionally normative" because their problem solving is conditioned by normative assumption.[13/] The economists in this numerically important group envision their role as that of providing the positivistic information necessary to solve problems involving energy and food defined in terms of a set of given values. As such they play a partial rather than a complete problem solving role. Kenneth Parsons, an institutionalist, views the work of conditional normativists with horror because he fears that the assumed values will take on the nature of dogma and not be subjected to either logical analysis or the tests which rise out of problem solving processes and experience.[14/] Georgescu-Roegen's book on entropy and the economic process is very pragmatic and extends the pragmatic argument to physics, the disciplinary stronghold of the positivists. Georgescu-Roegen argues that it is impossible to have a physics based upon prior definitions of variables, categories and classes for, says Georgescu-Roegen, physics deals with energy and different forms of entropy and man, he continues, values low-level entropy of various forms in different ways. Because of the different values which man attaches to different levels and forms of entropy, the variables, categories and classes with which physicists are concerned in studying heat and energy (entropy) are conditioned by those values which change with entropy. Georgescu-Roegen then concludes that the process of studying changes in entropy (energy also) changes the variables, classes and categories which physicists

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13/ Johnson and Zerby, op cit., Chapter 1.

14/ Kenneth Parsons, The Value Problem in Agricultural Policy, Agricultural Adjustment Problems in a Growing Society, Iowa State College Press, Ames, Iowa. 1958. p. 296. Also see Science, 15 March 1974, Ibid.

define and use. Thus, Georgescu-Roegen destroys positivism and along with it the need for conditional normativism while doing a great deal to reinforce the arguments of the pragmatic institutionalists. And, he does this in physics, the strong hold of the positivists! fail to see how we can discuss the roles which economists should play in studying energy and food problems without recognizing the fundamental importance of this recent contribution by Georgescu-Roegen to the literature of economics, econometrics and physics.

As I see it, our credibility gaps with decision makers often arise because our work is not normative or pragmatic enough for them; on the other hand, our difficulties with our bio-physical colleagues often arise out of their positivism when they play the role of scientists or their dogmatic normativism when they play the role of concerned citizens. Decision makers define and solve problems in normative terms--in doing so they develop normative concepts. When our research is either conditionally normative or positivistic we lose credibility by being less capable on the normative side than those we try to help. By contrast our positivistic colleagues in the bio-physical sciences feel that it is unscientific to deal with the normative; hence, we appear unscientific to them when we deal with values (monetary as well as non-monetary) in pragmatic, conditionally normative, or normative ways. On the other hand when our bio-physical friends "leave their laboratories" to become "concerned citizens" their positivism causes them to dogmatically place the values they advocate above the tests of experience and logic in ways unacceptable to the more objective (see p. 25-6) pragmatic and normative workers among us.

Difficulties with our Theories:--Some of our difficulties with theories are closely related to our difficulties with philosophy. They involve the normative time consuming nature of production, our ceteris paribus assumptions, and the preconditions for maximiation, the later including the interpersonal validity (or lack thereof) of welfare measures.

Recognition that production is normative is in keeping with long standing traditions in economics. Not only have we long regarded production as being the creation of time, form and place utility, but Frank Knight has pointed out that what goes into a production process comes out. He pointed out that we differentiate what comes out into that part which has value--which we call product--and that which does not have value--which we call waste. Of course this makes nonsense out of distinguishing between technical and economic efficiency according to whether or not values are taken into account; obviously, if values are not taken into account, the technical or physical ratio between what goes in and comes out of a production process is always one! Our own failures to understand and clarify this is at the root of many difficulties with decision makers and our colleagues in other disciplines.

Another difficulty with our theory is the timelessness of its production and consumption function concepts. These concepts ignore the passage of time which takes place during the process of production and consumption. Ray Bressler was concerned about ignoring the passage of time in the production processes. He and his associates concentrated upon this difficulty in studying the time-consuming creation of time, form, and place utility by marketing firms. Their engineering approach dealt with what goes on within the production process rather than with just the inputs into and outputs from the process. They were interested in throughputs as well as inputs and outputs.

Applications of economic theory which either ignore the normative nature of production processes or the time required in production processes are not likely to attain credibility among decision makers (public or private) concerned with problems involving energy and food. They sense intuitively or out of their experience with the real world that something is wrong with a theory that ignores passage of time and does not recognize inherently that production involves the normative creation of time, form and place utility. If, in addition to studying time within production processes, we follow Georgescu-Roegen and let our normative definitions of products be functions of problem solving processes, we have more difficulties with our concepts of production and consumption functions. And, that is precisely the joint consequence of what Bressler and Georgescu-Roegen have had to say. Energy is a component of entropy. Food is a form of entropy. Entropy and economic processes interrelate our concepts of normative and positive variables in a pragmatic way. Thus, the very meaning of production is a function of our attempts to solve problems involving food and energy.

Another difficulty with our economic theory which also creates a credibility gap with public and private decision makers has to do with our ceteris paribus assumptions. We typically assume that changes in technology, institutions, and human beings do not take place. We do this to secure a static economics which is easily handled mathematically and conceptually. In contrast to the assumptions of our theory, problems involving energy and food typically grow out of the changes in institutions, human beings and technology. In economic theory we seek solutions assuming fixed technology, institutions and people. In the real world we go

beyond the market to seek non-market changes in technology, institutions and people. We need only review the events of the last year to see how changes in international institutions have generated a whole series of problems involving energy and food. Similarly it is not hard to see the connections between human and technical change in creating problems involving food as well as energy and it is clear that the solutions involve both market and non-market adjustment unless the market is defined as going beyond free exchange to include the use of power and coercion.

One of the deeper reasons for assuming the absence of institutional, human, and technical change in static economics is to avoid, in theory, the problems of evaluating changes which impose damages upon some persons while conferring benefits upon others. Ever since the full significance of Pareto's question about the interpersonal validity of welfare measurements was realized, we have tried to develop a theory which would permit us to either (1) reach welfare judgments involving the imposition of damages upon some persons in order to confer benefits upon others or (2) avoid the difficulty. We have been more successful in avoiding the difficulty in theory than in practice. On the evaluation side, by contrast, we have made only minor progress in theory and a bit more in practice with respect to simulation and social indicators. Thus, we lack capacity to resolve important practical problems involving food and energy arising from our dynamic institutional, human and technical environment and tend, by default, to confine ourselves to recommending that we let the market take its course in reaching a very limited set of Pareto-better adjustments including technical, institutional

and human induced by the maximizing activity of man. I say limited set because the only Pareto-better adjustments which the market can be expected to reach itself are those which it would reach under the assumption that all resource owners (who are also consumers) are perfectly informed. If people are not perfectly informed and if transaction costs introduce differentials between acquisition and salvage prices, then the market cannot be trusted to reach Pareto-better adjustments to institutional, human and technical changes.[15/] We have real difficulties when the present distribution of rights and privileges with respect to food and energy is the problem, as is generally the case, and the solution is likely to be forced institutional, human, and/or technical changes which will damage some in order to benefit others. Making such changes ordinarily involves use of social, military, political or economic power, force and/or coercion. A theory which fixes technical, institution and human variables is of little value in choosing among solutions involving the use of power, force and coercion to bring about such changes. If, in addition, the theory denies the possibility of interpersonally valid utility measures it is virtually useless. Decision makers sense this uselessness and we lose credibility.

A related difficulty with our theory is that the concepts of aggregate output and welfare, on one hand, and the distribution of the ownership of rights and privileges, on the other, are interrelated. The meaning of output for a community is determined by who owns what rights and privileges with respect to food and energy. Discussions of trade-offs between output and more or less equality in access to food and energy which do not recognize that the meaning of output depends on rights of access to energy and food

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[15/] Johnson, Glenn L., Project Director/Leroy Quance, The Overproduction Trap in U. S. Agriculture, Baltimore: Johns Hopkins Press, 1972. Pp. 28-33, 42-44.

are likely to be misleading if not meaningless. The second world food conference in The Hague confused this issue and I suspect the one in Rome this fall will not clarify it.

Another difficulty which decision makers sense in our theory and practice is our tendency to use unrealistic assumptions which establish the preconditions necessary for maximization.[16/] We use these assumptions implicitly, at least, in assuming maximizing behavior on the part of entrepreneurs and consumers to derive supply and demand curves and estimate equilibrium levels of: (1) resource use, (2) product and input prices, (3) output, and (4) consumption levels. We also use these same assumptions, implicitly at least, to establish the preconditions for maximization in deriving policy, program and project recommendations to decision makers.

The preconditions for maximization include:

1) the existence of a common denominator among the goods being sought and the bads being avoided in order to define an objective function to be maximized as a basis for selecting the right action to use as a goal to be executed,
2) either the interpersonal validity of that common denominator or that it is never used to reach decisions involving the imposition of damages upon some in order to confer benefits on others,
3) the existence of a maximum to be found, this precondition

[16/] Essentially, there are the assumptions of static economics as outlined by Frank Knight in his "Risk, Uncertainty and Profit" plus the assumptions required to make it unnecessary to examine Pareto-better changes.

ordinarily being referred to in mathematics as the second order condition necessary for the existence of a maximum,[17] and

4) an agreed-on decision rule for defining a maximum.[18]

Difficulties with our Techniques:--In addition to the inappropriate roles which we sometimes play and the deficiencies of the theories we employ, economists are sometimes excluded from studies of energy and food problems because of the techniques they employ. It is not that we are poor mathematicians or statisticians; to the contrary, we are typically in the lead among agricultural disciplines in our command over statistics and mathematics. Instead, the difficulty seems to originate in the inadequacies of our theory which in turn limit the techniques we employ. For instance, the emphasis of our theory upon maximization causes us to use quantitative techniques which estimate the supply, demand and equilibrium prices on the implicit assumption that all producers and consumers have already met the preconditions for maximization. This causes us neglect the processes whereby producers and consumers establish the preconditio for maximization and to fail to participate with public decision makers in such processes. Our bio-physical colleagues concerned with food deal with technical processes which they research and try to improve. The changes which they make destroy prior entrepreneural and administrative knowledge of the

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[17] We insure the existence of optima in economic theory with the assumed mathematical form for production and consumption functions and by, as was noted above, ignoring the passage of time within production and consumption processes.

[18] Under perfect knowledge and foresight the decision making rule is simply that of subtracting the bad from good, both measured in terms of a common denominator which has to be interpersonally valid if more than one person is involved; however, if imperfect knowledge is involved there is a wide range of decision making rules which could be used including the use of chance, the mini-max principle, etc. and about which there is no agreement as to the most important.

preconditions for maximization making it necessary for decision makers and their staffs to spend time in reestablishing those conditions.

Starting before and continuing after World War II, economists acquired a considerable capacity to work quantitatively with statistics, mathematics and maximizing models. Among the maximizing techniques which have been developed, widely used, and advocated by economists are production function analysis, the use of the simultaneous equations, cost/benefit analysis and linear programming in its various forms including multiperiod and recursive LP, etc. In the Cowles Commission, then at the University of Chicago, the simultaneous equations technique for estimating parameters of sets of simultaneous equations was developed. Those equations typically assumed producers to be profit maximizers and consumers to be utility maximizers. Thus, the systems of equations typically developed by econometricians were rather specialized and presumed the satisfaction of the preconditions necessary for locating optima. Also, as modern computers increased the importance of linear relative to non-linear algebra, economists took the lead in developing linear programming procedures for locating optima in constrained linear systems. Similarly there was a substantial development in the post-war period with respect to input/output analysis and benefit/cost analyses. While all of these techniques represented substantial, specialized steps forward, the cost paid for specializing was lost generality with respect to types and sources of information used, other techniques, and especially with respect to other disciplines to supply both theories and different kinds of information to make projections involving different specific problems.

Elsewhere I have summarized in some detail, the experience of economists working with the specialized theories and techniques in the interwar period.[19/] That summary indicates that decision makers have long relied on projections in solving practical

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[19/] Chapter in forthcoming book by TransAtlantic Conference on Agriculture Change being produced by a project financed at the University of Wisconsin Social Science Research Center.

problems and that the post-war work of economists has not been general enough with respect to types and sources of information and theory to handle the practical problems of decision makers which are (1) multidisciplinary in nature and (2) occur in contexts in which the preconditions for maximizing behavior and decision making are not met initially but have to be established.

In general many of the techniques developed since World War II can be characterized as: (1) unduly specialized upon maxima, (2) focused on economics to the exclusion of the institutional, humanistic and technical disciplines, and (3) unduly restricted to sources of data within economies such as, for instance, time series data.

Projections and Simulations as a Way to Attack Problems Involving Food and Energy

I believe we can see a way out of our difficulties with our roles, philosophies, theories and techniques by examining the history of the use of projections by public and private decision makers. I suppose, decisions have been made on the basis of capacity to see the consequences through time of alternative courses of action. This continues to be the case <u>despite</u> the advances economists, statisticians and econometricians have made in quantitative techniques since World War II. Decision makers use projections to see the consequences of the alternative courses of action open to them through time in order to decide better which of the alternative courses to take. Recently, the computer has made it possible to make projections more rapidly, more flexibly and at lower cost than in the past. This, in my view, is now opening up a new realm of possibilities we are only beginning to learn to exploit. It is this opportunity I want to dwell on today.

Out of attempts to use the computer to make projections has come what I call general, systems-science, simulation. I believe this approach is capable of recovering the generality and flexibility of traditional projections and of using the advances made in more specialized quantitative techniques since World War II. Fundamentally this approach is not different from that followed by those doing the projections work for various public and private decision makers. Ideally, it exploits the strengths and potential contributions of any relevant discipline, source and kind of information, or technique; hence it is an approach, not a technique. It differs from traditional projections mainly in exploiting the computational efficiency of the modern computer.[20/]

One has to be careful in using the word "simulation" for it has a variety of meanings to different workers. Above, I have used the adjectives "general" and "system-science" before the noun "simulation."

I use the word "general" to mean that the simulation is not to be specialized on the subject matter of any discipline, on any particular source of any particular kind of information, or on any particular techniques. Thus, to repeat, it is an approach, not a technique. The meaning of the word simulation cannot be confined to say, a recursive linear program, (RLP) which will trace out the consequences through time of following an alternative course of action though general, systems-science exclude or renounce potential desire to use RLP. The word general does not permit specialization upon any particular technique to the exclusion of another and is used to keep the approach general enough to maintain credibility with decision makers concerned with real world problems. Similarly the adjective general indicates the intent to use, not use, or defer use of maximizing components and techniques.

[20/] Other than what has been stated above I will not enter into arguments about the use of quantitative models of human systems. Some readers may be interested in The Dynamic Programming of Human Systems, a Social and Historical Analysis by John Wilkinson, Richard Billman and Roger Garandy or Occasional Papers for the Center for the Study of Democratic Institutions, MSS Information Corp., 655 Madison Avenue, New York, NY.

The adjective "system-science" is used to indicate that the approach includes the various techniques which system-scientists have developed for linking and interfacing components based upon such specialized techniques as simultaneous equations systems, PERT, benefit/cost analysis, I/O analysis, etc. However, the adjective general precludes concentration on the techniques of systems scientists to the preclusion of other techniques, i.e., we are concerned with more than recursively-linked differential equations.

One of the important things which both traditional projections and general, system-science simulations provide is a process whereby decision makers can partially, at least, establish the preconditions for making maximizing decisions. Obviously, decisions are made eventually on the basis of some attempt to maximize, i.e., to do that which is right in view of the various goods and bads which can be attained or imposed upon different groups of people through time.[21/] Research staffs and investigators can make projections to see what kinds of goods will be conferred upon what groups of people when and where. Similarly they can make projections which will tell decision makers something about what kinds of bads will be imposed upon what groups, when, and where. If there is a continuing interaction or dialogue between projection-making investigative staffs and decision makers (including those affected), initial computations as to who will be affected in what ways, when, and where can lead to subsequent computations to refine the simulations

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[21/] C. I. Lewis, The Ground and Nature of the Right. New York: Columbia University Press, 1955.

even more. Out of such pragmatic interactions between investigators and decision makers (including those affected) comes an increasing knowledge of the trade-offs among different goods attainable and different bads avoidable.[22/] As knowledge about the trade-offs among goods and bads develops in this interactive, iterative process, such knowledge also takes on a degree of interpersonal validity (see pp.25-6, item 6 for criteria of objectives). Though perfect knowledge of common denominators and perfect interpersonal validity is not generally attainable, decision makers and investigative staffs do attain enough interpersonal validity to make decisions concerning non-Pareto-better technical and human change.[23/] Many problems involving food and energy typically can be solved only by making such changes.

We also noted that under imperfect knowledge and foresight an "agreed upon" decision rule is a precondition for locating a maximum. Clearly, problems involving food and energy are typically solved in situations of imperfect knowledge. General, system-science simulations are particularly useful in envisioning the consequence through time of using alternative decision making rules. As decision makers gain ability to see the consequences of adopting different decision making rules, they are better able to choose which decision making rule should be used. Again, interaction between decision makers and investigative staffs is fundamental as are iterative projections

[22/] Glenn L. Johnson and Leroy Quance, op cit., p. 51 and Chapter 11. Here the approach is traditional. For a less traditional, general, systems-science approach see G. E. Rossmiller, et al., Korean Agricultural Sector Analysis and Recommended Development Strategies, Agricultural Economics Research Institute, Seoul, Korea and Department of Agricultural Economics, Michigan State University, East Lansing, Michigan, 1972, Chapters IV and VII.

[23/] See Glenn L. Johnson and Lewis K. Zerby, op cit., Chapters 1, and G. E. Rossmiller, et al., op cit. pp.

Exploiting General, System-Science Simulation in Studying Problems Involving Food and Energy

In order to exploit fully the general, system-science simulation approach to the study of problems involving food and energy, there are a number of guidelines which are worthwhile following. These guidelines grow out of experiences of persons following the approach in connection with research on practical problems of decision makers.

1. The domain to be modeled is the domain of the real world in which the problem under consideration exists. Such domains ordinarily have both time and space dimensions. Further, the domain is generally multidisciplinary in character and requires for its modeling descriptive information and theoretical concepts from many disciplines. As a general rule the discipline of economics accounts for much less than half, say 10 or 15 percent, of the domains to be modeled. This guideline implies that problem definition and concentration on problems is the first order of business for those concerned with problems involving food and energy.
2. Models to be used for practical problem solving purposes must take value (normative) as well as positive variables into account. Ordinarily, in a general, system-science simulation model, these variables are referred to as performance variables. In a specialized simulation model based upon recursive LP the single performance variable would be referred to as the objective function.
3. Guideline 2 implies another guideline. It is that persons modeling the domains of practical problems should be flexible and general with respect to specialized philosophies such as positivism. More specifically they should avoid the constraints

of various specialized philosophic positions. Their philosophic orientation must permit them to work with both the normative and positive.

4. Another guideline with respect to the contributions of economics is that the contribution has to be of the highest quality. Generally speaking our economic theories and quantitative techniques are still deficient and unable to handle important aspects of the economic parts of the domains to be modeled. Thus, we have much relevant disciplinary work to do to support problem solving research on problems involving food and energy. While recognizing this need for quality, we must also recognize than many economic theories and techniques regarded to be of high quality are unduly specialized on economics and on maximization and of limited value. To be either an econometrician or L.P. expert is not adequate to be a general, system-science simulator.

5. We must recognize that considerable progress has been made with respect to using the general, system-science simulation approach by disciplines other than economics. In the biological sciences, for instance, a substantial amount of work has been done on biological and physical systems involving the design of new plant varieties, the design of water management systems and in handling energy flows. Clearly, it is time for economists and bio-physical agricultual scientists to work together to put their various components into overall models of domains containing real world

problems involving food and energy.[24]

6. Interaction with decision makers (including persons affected) is necessary in order to develop models of problematic domains. This interaction is itself a source of the information required to establish the preconditions for optimization.

7. Another guideline closely related to the second above is that no available source of information should be excluded from use. Included among the sources are time series data, surveys, the judgments of experienced people, and experiences with the goodness and badness of various conditions, situations and things important in the solution of problems involving food and energy.

8. The last guideline to be listed has to do with criteria for truth and, of course, is closely related to generality with respect to philosophic positions. Generally speaking models are rejected if they fail to meet any of the following criteria:

   a) Consistency with observations and experiences with the real world.

   b) Logical internal consistency.

   c) Clarity to permit them to be communicated from one individual to another when the individuals have had similar experiences and have had access to the same descriptive information and theoretical concepts.

[24] Duckham, A. N. and J. G. W. Jones, Human Food Chains and Nutrient Cycles, North Holland Publishing Company. Forthcoming, Chapter 21.
McKelvey, John J., op cit., Chapters on Agricultural Systems and Systems Studies.

d) Workability when used to solve real world problems. Models are rejected when they flunk one of these tests. Obviously, an "accepted" model or component of a model may later flunk one of these tests; hence, all accepted models are only tentatively acceptable. Objectivity consists of a willingness to use tests based on these criteria and to abide by the results.

9. We must be willing to join problem solving teams as indians as well as chiefs. To do this well, we require improved administrative structures for doing problem solving research. I have made suggestions elsewhere on how to bring about this improvement.[25/]

In Conclusion

I want to close on an optimistic note, economics and economists have much to contribute to the solution of problems involving food and energy. We have the best developed body of theory in the social science. We have made substantial progress on quantitative techniques. We now have an over-all approach in which we can incorporate those theories and techniques to address ourselves to problems involving food and energy as parts of problem solving teams including personnel from other relevant disciplines. Further, we have great capacity to improve our theories and quantitative techniques. It how behooves us to participate in the definition and solution of problems involving food and energy.

[25/] Johnson, Glenn L., "The Quest for Relevance," Journal of American Agricultural Economics Association. Proceedings Issue, Fall Meeting, 1971.