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SYSTEMS SIMULATION AND ITS APPLICATION IN THE KASS APPROACH

BY: Glenn L. Johnson

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SYSTEMS SIMULATION AND ITS
APPLICATION IN THE KASS APPROACH

by

Glenn L. Johnson*

One of the first things to do in addressing people interested in using results of simulation research to help solve agricultural development problems is to answer the question, "What is simulation?" Even if this were a speech to professional simulators, it would be necessary to indicate the specific meaning which I want to attach to the word because there are many, many different types of simulators, each type calling a somewhat different thing simulation.

I am going to talk about "generalized, computerized, systems-science" simulation. Such simulations are general because they are not specialized with respect to type or source of data, technique, discipline, or philosophy. They are adapted to utilize modern, high-speed, electronic computers and, hence, can be referred to as computerized. They also deal with the structure of systems and the activities which go on within such systems; hence, the approach of systems scientists is advantageous and simulations involving their work can be referred to as systems science simulations. Though systems scientists made their name in the aerospace industry originally, the systems science approach is applicable to any system including environmental or ecological systems; economic, social and political systems; and, of course, agricultural systems.

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Having discussed briefly the meaning of the adjective "generalized," "computerized" and "systems science," it remains to discuss the meaning of simulation as a noun. The word is used here to stand for a representation of a real world system which is capable of tracing the evolution of the system and activities generated within that system through time. The two essentials are that the system represent or be thought to represent at least some aspects of a real world system and that it be capable of operating through time. Examples include ship testing basins and pilot plants as well as mathematical representations of such operating systems as space programs, hospitals and agricultural sectors. Models can also be expressed in English rather than in mathematics and, as such, can be still representative of real world systems at points of time and through time. The simulation models that are to be discussed herein represent systems from the real world in terms of equations capable of being put on computers.

Why Simulate?

When one is asked the question, "Why simulate?" the experienced simulator is likely to answer, "because real world decisions concerning practical problems are almost always based upon knowledge concerning: (1) the structural nature of an existing or newly designed system about which a decision is being made and (2) how that system would operate through time." This answer is true historically as well as currently and will continue to be true for the indefinite future. Such an answer indicates that simulation is not a new thing dependent upon recent advances in computer technology. The answer recognized that down through the ages it has been important for military leaders, kings, presidents, ministers and legislators to understand the structure of the systems they are trying to modify and to envision how the system's behavior would be affected by their decisions. Even before the advent of the written word, it is likely that the family, governmental, and military decision-makers who attained the greatest successes were those who did a superior job of envisioning the system in which they existed including how it would operate through time if various modifications were made in it. In Korea, Admiral Lee, Soon Sinn must have been a superior simulator to attain his great victory over the Japanese fleet.

My own early experiences as an agricultural economist includes a period of pre-computer research in the Statistical Service Section of the Division of Historical and Statistical Research of the old Bureau of Agricultural Economics in the U.S. Department of Agriculture. The section served administrators from the executive branch and senators and congressmen from the legislative branch of the U.S. Government. It was continually engaged in developing statistical pictures of the structure and nature of the U. S. agricultural economy or of some part thereof which was particularly relevant to then current problems and issues before administrative and legislative decision makers. As a young, Number 10, junior professional assistant in the Department of Agriculture Civil Service, I was asked repeatedly to make projections concerning the consequences through time of alternative legislative and administrative actions. At that time, econometricians had not yet developed the simultaneous equations technique of estimating the parameters of sets of simultaneous equations; hence, the specialized simultaneous econometric equations of the Cowles Commission variety were not used. Also, as linear programming had not yet been developed, specialized single-period, static and multi-period dynamic and recursive linear programming were not employed. However, both mathematical and graphic correlation techniques were employed on occasion while a great variety of economic, political, technological, sociological and administrative concepts and theories were used. A great diversity of information was mobilized from "situation report writers" who had responsibility for accumulating various kinds of information from many sources concerning various commodity and subject matter areas. Supplemental information was obtained from lawyers, farmers, old mail order catalogues, agronomists, animal husbandrymen, business men, sociologists, demographers, government administrators, congressmen, etc. This information was assembled on an ad hoc, flexible, seat-of-the-pants basis into a picture of "the situation" relevant to the problem at hand. Projections were also developed for alternative policy, program and project designs. These projections were developed laboriously, but flexibly, with paper, pencil, desk calculator and hunch until a reasonable picture was obtained of how the existing system looked, operated and would be modified by the legislative and administrative proposals under consideration. Also, there was a great deal of interaction between the people making the projections and the decision makers. For a person as junior as I was at that time, the interaction with senators, congressmen, and government administrators was often with my supervisors rather than directly with me though it was not too long before it was clear that administrative and legislative decision makers wanted to talk directly to the person making the projections. Oftentimes the decision makers did not like the projected consequences of their own proposals and wanted to develop still other alternatives. In doing this, they wanted to talk to persons more capable than they were of describing the existing situation and of envisioning the consequences of their alternatives through time; hence, they sought direct contact. And, I as the person making the projections found such interaction an important source of information.

The interactive process which was just described is far from unique; instead, it is characteristic of real world decision making, both public and private. Essentially, it is a staff/decision-maker relationship usually found between staff and decision makers in the military as well as in other administrative branches of the government and between legislative staff members and legislators. It is also the sort of working relationship which exists in businesses between decision makers and their staff. This interaction is crucial for the success of both investigator and staff. With interaction more information is available to investigators and staff and is used; without it some information is likely to be wasted. With interaction, the projections take on credibility with decision makers because they have an opportunity to supply ideas, information and to understand the projections; without interaction decision makers are left uninformed, deprived of opportunity to contribute valuable ideas, and have suspicions of the results produced by their investigators.

One of the disadvantages of paper and pencil, seat-of-the-pants, ad hoc projections is their high cost. They require large inputs of expensive professional time and the slowness with which computations can be made make it difficult to make projections for more than a few alternatives at a few points in time.

In the 40's and 50's, there was a period of time in which considerable mathematical and statistical progress was made with respect to very specialized techniques. One "leap forward" came at the Cowles Commission at the University of Chicago where the technique of making probability estimates for parameters of systems of simultaneous equations was developed. At the time this development was taking place, there was a great deal of hope that it would make the informal kinds of projections described above much more accurate and hence more effective; however, the technique did not live up to its promise. Retrospectively, the difficulty seems to be that the technique of making probabilistic estimates of the parameters of simultaneous equations was: (1) unduly specialized on sources and kinds of data; (2) dealt only with linear relationships when non-linear ones should be used; and (3) often assumed maximizing behavior on the part of producers and consumers who have not yet "sorted things out" well enough to maximize. Primarily time series and, in some instances, cross-sectional data were used. It was difficult to incorporate experimental data and prior information to which probabilities could not be assigned and the information contained in the judgments of administrators and experienced personnel.

Another development had to do with linear programming which has also been computerized. Linear programming computations are maximizing computations and require the selection of a single objective to be maximized. After its initial development, linear programming was extended so that programs could be run recursively and, hence, used as specialized simulation models.

As linear programming models must maximize something, they, like the systems of simultaneous equations developed by econometricians, are of limited usefulness in exploring the structure of systems and the behavior of persons and organizations not yet able to determine what to maximize. Simultaneous equations and linear programming projections have not achieved the wide acceptability of seat-of-the-pants projections among decision makers and important credibility gaps have developed for these techniques. These gaps have not been easily bridged by interactions between investigators and decision makers for a number of reasons. Included in these reasons are the complexity of these estimation techniques, the the narrow range of information used by investigators who often ignore information readily available to decision makers, the obvious premature or inappropriate uses of maximization, and the exclusion of the creative and inventive ideas of decision makers. The unfavorable experiences of decision makers and administrators with projections produced by such highly specialized techniques have produced a suspicion of all computerized sophisticated estimate and a tendency to prefer common-sense, more understandable, broader based, less specialized projections.

As more specialized approaches such as simultaneous equations and the linear programming techniques have less flexibility than the old paper and pencil, seat-of-the-pants projections, there is a need to maintain flexibility in modeling the structures and operations of real world systems. Generalized, computerized, systems-science simulation models have been successful in maintaining the flexibility of the seat-of-the-pants projections while exploiting the computational efficiency of the modern electronic computer and utilizing such specialized techniques as linear programming and econometric estimation of parameters of simultaneous equations; thus, part of the answer to the question of "Why simulate?" is that simulation can maintain the flexibility of the more creditable traditional seat-of-the-pants projections with respect to sources of data, kinds of information, disciplines and specific techniques without being constrained to specific types and sources of information, specialized techniques, or a single philosophic point of view. Furthermore, simulation can deal with multiple objectives without necessarily maximizing or assuming maximization behavior. Like the old seat-of-the-pants projections, simulation can permit creative, inventive, and original interactions with decision makers.

At this point, it is worthwhile to illustrate the decrease in costs which has been made possible by the use of systems science techniques and electronic computers in making projections. Neither systems science techniques nor the computer reduce the flexibility of the old seat-of-the-pants approach yet, together, they greatly reduce costs for a given system of any important degree of complexity. This can be illustrated from experiences in carrying out agricultural sector analyses of the development problems of two countries--Nigeria and Korea. Using seat-of-the-pants traditional projections for Nigeria, an inter-university team expended 30 professional man-years of time constructing projections for three main policy alternatives at three points in time for Nigerian agriculture.[1/] In this connection, it was necessary to amass a great deal of information about the Nigerian agricultural situation. The project took three years. It was expensive. It did attain acceptability. The Nigerians used the final report along with an earlier report from FAO on Nigerian agriculture as the two basic resource documents for a six month agricultural development planning exercise and seminar. This planning exercise and seminar became the basis for the "perspective" agricultural development plan which is the basic input concerning agriculture into the development of Nigeria's next five-year plan. The high cost of making these seat-of-the-pants projections was impressive; as a result of these high costs, steps were taken to investigate the possiblity of using the generalized computerized systems-science, simulation approach. At a national conference of persons informed concerning this approach, it was concluded that the necessary software had not yet been developed. Fortunately, the Agency for International Development contracted with Michigan State University to proceed to develop such software with the hope that the cost of doing subsequent sector analyses could be greatly reduced. Subsequently, it costs about one-fifth of what the Nigerian study cost to develop the necessary software to model the

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[1/] Johnson, Glenn L., *et al.*, "Strategies and Recommendations for Nigerian Rural Development 1969/1985," Consortium for the Study of Nigerian Rural Development, July, 1969.

Nigerian economy.[1] This software was developed by the time the Nigerian Agricultural Development Seminar was held. In connection with that seminar simulations were run for 17 policy alternatives by years for twenty years into the future at a cost of less than 2 percent of what the original seat-of-the-pants projections cost for these alternatives at three points in time.

Shortly after this, The Korean Agricultural Sector Study was done. Many of the software components developed for Nigeria were directly transferable to Korea. The main problem was to quickly amass a description of the current Korean situation. This was done utilizing the services of about 40 persons who were not particularly oriented to systems-science simulation modeling. However, the systems scientists and agricultural economists involved who were oriented towards such simulation modeling used their knowledge of such models and modeling techniques to guide the activity of the 40 or more non-simulators who participated in the Korean study. This greatly increased the efficiency with which observations were made on the existing economy. Further, the simulators were able to build that information quickly into mathematical equations which could be placed on the computer. This meant that the Korean group, unlike the Nigerian group, did not have to spend large amounts of very expensive professional time carrying out paper and pencil and desk calculator computations. The upshot of it was that the Korean's agricultural sector study document reached first draft stage within 7 months rather than 36 months at a cost of approximately one-fourth the cost of the Nigerian study.[2] Still further, the Korean model

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[1] Manetsch, Thomas J., et al., A Generalized Simulation Approach to Agricultural Sector Analysis, Consortium for the Study of Nigerian Rural Development, November, 1971.

[2] Rossmiller, G. E., et al., Korean Agricultural Sector Analysis and Recommended Development Strategies 1971-1985, Korean Agricultural Sector Study Team, 1972.

was much more comprehensive and dealt with many more policy alternatives in much more detail than the original seat-of-the-pants projections for Nigeria. Clearly, there has been a substantial reduction in costs of making projections without losing the flexibility and credibility of the old seat-of-the-pants traditional projections.

Incidentally, it must be stressed that the generalized, systems-science simulation approach is not to be compared with such specialized techniques as linear programming, simultaneous econometric equations, cost/benefit analysis, input-output analysis, etc. It is not a specialized technique; instead, it is an approach. As an approach, it utilizes any one of such specialized techniques if it is appropriate to use them. In utilizing such a technique, the approach could concentrate entirely upon the technique or merely use it to model some small component of the system being modeled. In many instances, the investigation reveals that it is not advantageous to utilize certain specialized techniques such as linear programming, simultaneous econometric equations or cost benefit computations.

What System Should be Simulated?

The building of a simulation model is like the building of, say, a working model of a ship or airplane. One does not set out to model in the abstract; instead, one models some thing. The system involved in the solution of the practical problem of concern is modeled in practical, problem-solving work.

The Korean Agricultural Sector Study (KASS) approach to the study of Korea's agricultural sector was practical and intended to assist in reaching prescriptions for solving Korea's agricultural development problems. KASS viewed its task as one of developing as much of the necessary information for making prescriptions as feasible within its resource limits. Included in the sources of information were decision makers from the Republic of Korea Government (ROKG); the United

States Agency for International Development, Korea (USAID/K); the Agency for International Development, Washington (AID/W) and from grantor, donor and lender agencies. The prescriptions reached in this study were not exclusively those of KASS, but were, instead, partially the outgrowth of interactions with relevant decision makers.

Reaching prescriptive conclusions to solve agricultural development problems required development of a picture of the Korean situation and of the desires and dislikes of Koreans.

The Problem-Solving Process

The problem-solving process, as diagrammed in Figure 1, includes six steps which all draw on and produce knowledge of both the Korean situation and of Korean likes and dislikes. Development problems of an agricultural sector grow out of changes or the lack of changes in its environment, mainly with respect to technology, institutions, and people. Acquiring knowledge about such changes requires the efforts of a wide variety of specialists such as technical scientists, political scientists, sociologists, psychologists and educators, statisticians, and students of business administration. The plant breeder, not the economist, is central to the solution of a problem that requires new plant varieties. Similarly, agronomists, chemists and biologists create new fertilizers, herbicides and pesticides; chemists, physicists, engineers, and designers create nonagricultural technologies; educators change people; and politicians and political scientists create new political institutions.

As Figure 1 indicates, both normative and nonnormative information are used in all steps of the problem-solving processes. A problem cannot be defined without normative concepts of goodness and badness as well as concepts about the current situation and how the system under study are

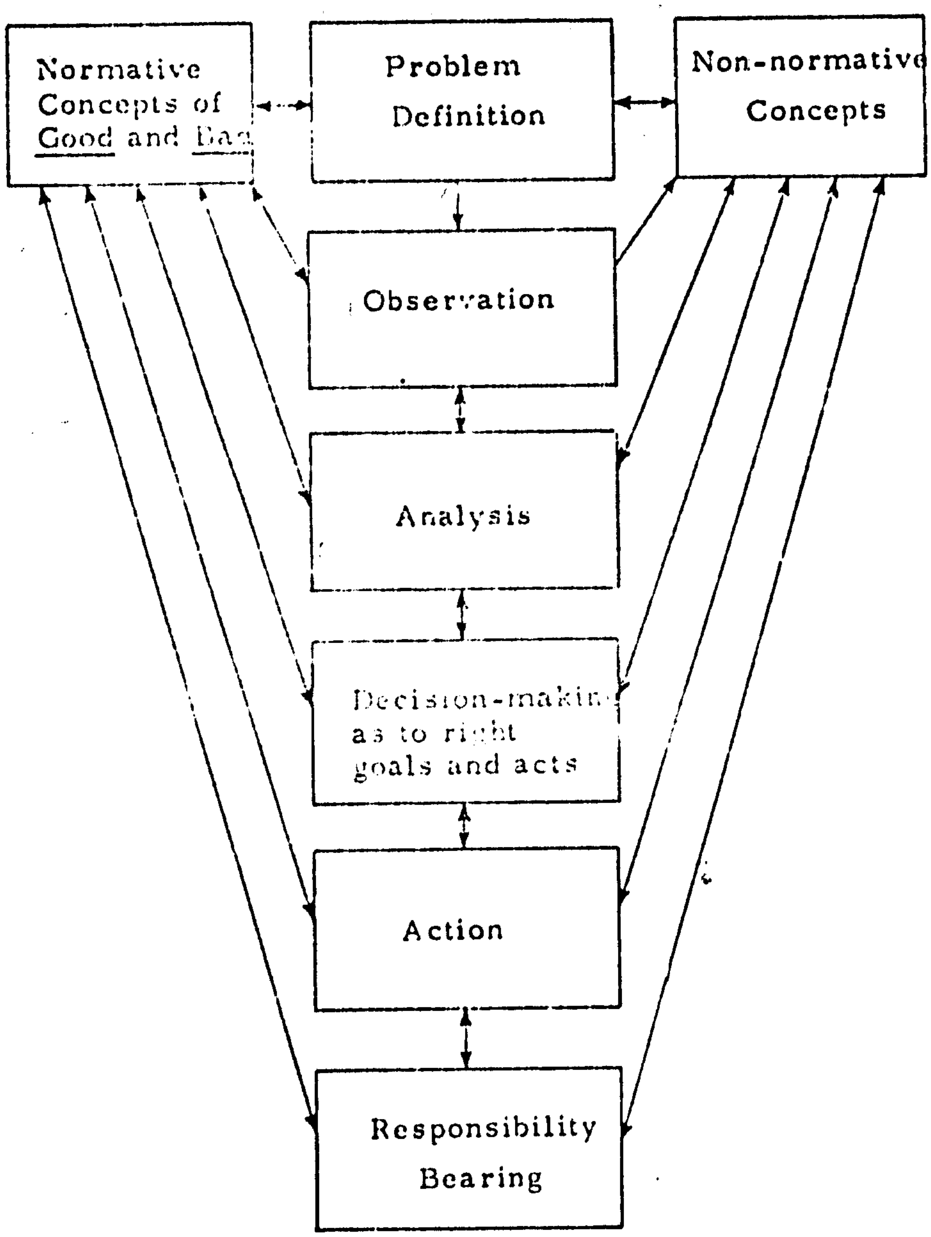

FIGURE 1. Six steps in a problem-solving process. (Source: Adapted from *A Study of Managerial Processes of Midwestern Farmers,* Johnson, G. L., Halter, A. H., Jensen, H. R., Thomas, D. W., eds., Iowa State University Press, Ames, Iowa, 1961. See also "The Role of the University in Economic Development," J. S. McLean Visiting Professor Lecture, Dept. of Ag. Econ., University of Guelph, Publication No. AE 70/2, March 23, 1970.)

related. Normative concepts indicate what is important and, hence, what kinds of nonnormative information should be observed and analyzed. The decision rules followed by decision makers utilize both normative and non-normative information to indicate which set of goals would, if attained through appropriate action, best "maximize Korean interests and purposes..." Action is, of course, oriented towards attaining the goals or targets judged by decision makers to be worthwhile, all things both normative and nonnormative considered. Responsibility bearing is, of course, both normative and nonnormative. The decision maker is responsible for the bad as well as the good consequences.

Noneconomists and certain forgetful economists need to be told that economics does, in fact, deal with the attainment of nonmonetary values, and that treating nonmonetary values as noneconomic is a serious error which results in elimination of consumption and welfare economics from the discipline of economics! It is hard to conceive of a single value about which questions of efficiency do not arise when trying to attain the value (if it is a good) or to avoid it (if it is a bad). Further, it is even harder to think of purely economic or purely social values; attainment of the so-called economic values is attended by social consequences, and conversely, as noted, there are economic questions of efficiency involved in attaining or avoiding the so-called social values. In effect, the dichotomy of economic and social values appears to be false.

Many of the problems of economic development do not meet the requirements for applying the simple calculus of economics in making decisions. The order in which actions are taken is often of crucial importance, yet the best order is not obvious. This is especially true where the problem involves invention and creation of new technologies, institutions and new kinds of people (through education and motivation, for instance). Also, it is difficult to find appropriate common denominators when trying to subtract the badness of, say, higher rice prices for poor urban dwellers from the goodness of greater national rice self-sufficiency. When a problem involves several individuals (as in a family, community or nation), the common denominator must have interpersonal validity if the calculus is to be applied. The remaining complication arises from imperfect knowledge. When outcomes of actions are uncertain, the "right" action is not always defined as the one expected to maximize the difference between good and bad. Instead, do decision makers, for instance, appropriately do that for which the worst that could happen is better than the worst for any other possible action? Or do they maximize the average expected difference? Or satisfice or flip a coin? Or fight or go to war to settle the question, especially if they are having trouble finding an interpersonally valid common denominator?

KASS investigators recognize that these difficulties would be encountered in attempting to solve the development problems of Korean agriculture. Like other problem-solving teams before them, KASS workers sought to handle these difficulties by studying both the structure of the agricultural sector and its problems to acquire an understanding of how the agricultural economy operates. However, unlike many other teams before them in many other countries, they also attempted to develop an efficient computerized capacity to project the consequences of prescribing alternative solutions to the problems of Korean agricultural development.

KASS Approach

The broad general development problem of Korean agriculture is made up of literally thousands of problems and sub-problems. Korea has a problem of attaining increased food production, in general and for specific crops; it also has a problem of high urban food prices and of low incomes to its farmers. The Korean diet is not adequate; more protein is needed, particularly meat, poultry products, fish, and dairy products. There is also a problem of population control. There is an income distribution problem within agriculture, within the urban sector, and between the two sectors. This income distribution problem also shows up regionally within the country. There is a problem of developing Korea's water resources and of controlling their use as well as of developing paddy and uplands. There are administrative problems in the agricultural establishment which interfere with the capacity of the Korean government to assist its agriculture. Farm labor problems are numerous, both for the farm entrepreneurs experiencing labor shortages and for laborers who find their earnings lower than those in Korea's rapidly developing industry. Korean farms are small and so fragmented that few people own enough land to produce incomes comparable to those emerging for people in the nonfarm sector. There is the problem of the low social status attached to agriculture and to farmers. There is a need to decentralize industry into rural areas. Korea's food markets are in need of modernization and rapid expansion; markets for modern sectors of production for agriculture are not well developed and function poorly. Economic intelligence available to the private agricultural sector and to the Korean government is inadequate.

Basic to solving the multiplicity of problems was the need to simplify the analysis and acquire an understanding of how Korean agriculture operates. The list of problems cited above could be expanded almost without limit, but it is already long enough to indicate that KASS could not tackle all the individual problems encountered in Korea's developing agricultural economy. Ways had to be found to economize on the time and resources of researchers assigned to the study.

The need to simplify the list of problems was closely related to the need to acquire an understanding of how Korea's agricultural sector operates, both internally and with respect to the other sectors of the economy. This understanding had to be relevant in the sense that it told how the agricultural sector would respond to policies and programs and, for that matter, projects designed to handle problems such as listed above. Korea's agricultural development problems were examined in enough detail to set up three broad alternative ways of organizing Korean agriculture to (1) simplify the analysis, and (2) acquire an understanding of how the Korean agricultural sector is put together, how it operates as now organized, and how it would operate if it were reorganized to follow alternative policies and programs. Thus, KASS has studied the three broad policy strategy alternatives for Korean agriculture which can be described briefly as:

1. Continuation of the agricultural policies and rural development strategies laid down in Korea's Third Five-Year Plan (TFYP),

2. Modification of the TFYP including higher agricultural product and consumer food prices and increased efficiency in attaining national agricultural goals through shifts in policy priorities and program emphasis from that plan, and

3. A policy strategy alternative involving greater Korean reliance on international sources of agricultural products and on the domestic market mechanism.

By concentrating on questions concerning the empirical consequences of following these three broad alternatives over the 1970 to 1985 period, the KASS team has been able to acquire considerable empirical understanding of how Korea's agricultural sector works. This deeper understanding is relevant to analyzing and solving the kinds of detailed problems taken into account in setting up the three broad alternative policy strategy sets.

Working Papers

After defining each of the three alternative ways of operating Korean agriculture, the KASS team raised questions as to what data and what subjects would have to be investigated in order to understand how Korean agriculture would operate under each of the three alternatives. Over twenty working parties were established and working papers produced. Each working party included a specialist in each particular subject from Michigan State University and one, two or even three Korean experts in the same subject matter. The working papers dealt with such subjects as crop and livestock production, upland development, credit, the National Agricultural Cooperatives Federation (NACF), water resources, price income and subsidy policies, research and technological advance, extension, rural institutions and infrastructure, administrative processes, population, capital formation, employment and migration, and nutrition. In several instances, the working paper teams developed informal projections based on a wide variety of data, information sources, and judgments. Later these projections were used as inputs in the more formal simulation model which was handled on a computer. Recognizing that information and skills from disciplines was required, the groups assigned to produce working papers included a sociologist, another trained in public administration, an extension personnel specialist, an industrial psychologist, an animal husbandryman, and an experiment station director as well as agricultural economists and systems scientists accustomed to working with a wide range of information about technical, institutional and human change. The importance of these working parties and papers in the KASS approach cannot be overemphasized.

While the various working papers were being produced, another group started the process of modeling the operation of the Korean agricultural economy. Michigan State University personnel, operating under AID/csd contract 2975, were available to transfer to the Korean model components which previously had been developed for work in Nigeria and Brazil.

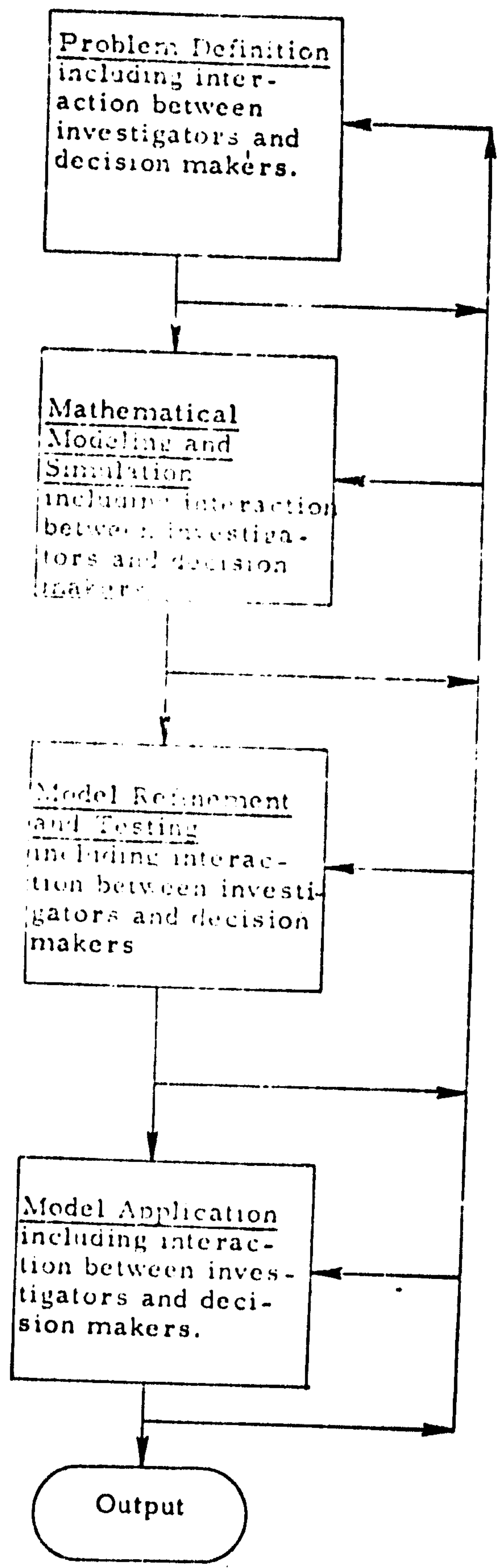

FIGURE 2 Model formulation as an iterative problem-investigating process.

There was constant MSU-Korean interaction between people writing the working papers and those designing the model. Information revealed by the working parties in each working paper changed the model and the model, in its turn, was the source of questions addressed to the various working parties. The many-faceted process of examining Korean agricultural development problems, defining those problems, establishing working parties and working papers, and of modeling the Korean agricultural economy was continuous, with steady feedback and reformulation as the project proceeded. Figure 2 diagrams the model development process and, as such, is closely related to the general problem-solving process diagrammed in Figure 1.

KASS personnel wanted a model of the Korean agricultural economy which would permit estimation of the consequences through time of following, not only the three policy strategy sets defined, but other alternatives as well. Because the Agricultural Economics Research Institute (AERI), the most directly involved Korean agency, has direct long-term responsibilities for economic research on Korea's agricultural sector, a model was designed to be (1) capable of handling a broad range of future policy alternatives, and (2) specific and relevant enough to the Korean situation to handle the three policy strategies in a manner directly related to Korea's agricultural development problems and her experiences with the TFYP.

To project the consequences through time of following the three alternative policy strategy sets, the model had to handle a set of variables which could be manipulated by analysts to correspond to each of the policy strategy sets. These policy variables are designated P in Figure 3. Figure 3 gives the reader a quick graphic view of the whole model developed by KASS. At the top of the

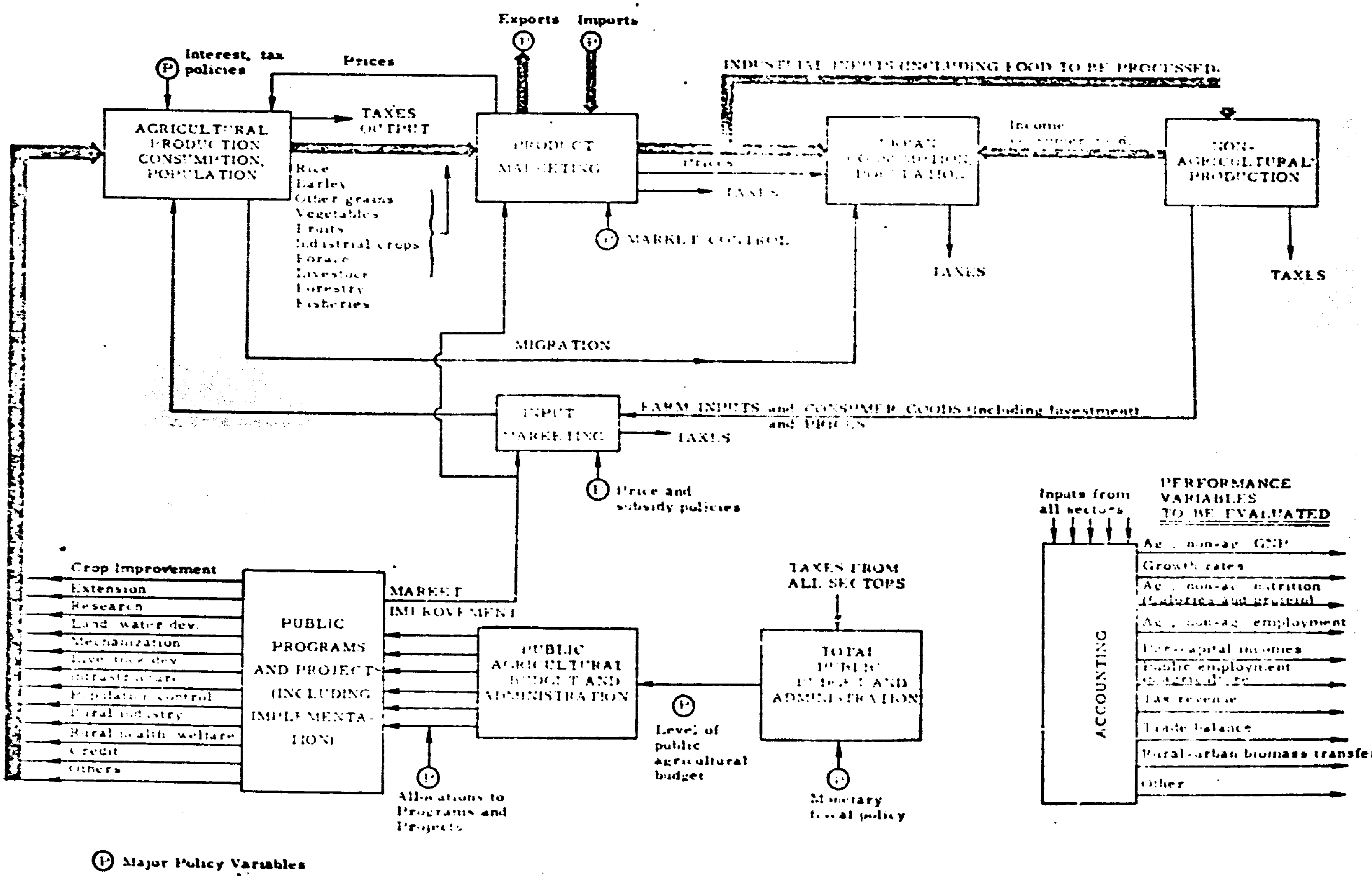

FIGURE 3. Korean agricultural sector analysis: major sub-sectors, flows, outputs, and policy inputs.

diagram are four major components of the model: (1) agricultural production and consumption, (2) agricultural product marketing, (3) urban consumption, and (4) nonagricultural production reached via an abbreviated version of the Korean National input/output table. More detail concerning the agricultural sector is provided by other major components dealing with agricultural input markets, public agricultural development programs, public administration, the national budget, and international trade. While the entire model shown in Figure 3 was not yet developed when this report was written, the diagram represents what the KASS group hopes to develop in Phase Two of its work. The strict time limitation imposed on this report by the contract between Michigan State University (MSU), the Republic of Korea Government (ROKG) and the United States Agency for International Development (USAID) made it necessary to work with an abbreviated version of the model which eventually will be constructed. That model is represented by Figure 4. Special attention should be called to different parts of Figure 4 to help the reader see that the model used by KASS is really a "man and computer" rather than just a "computer" model. The "man" components which are enclosed in dashed lines in Figure 4, include: (1) yield projections, (2) resource allocations, and (3) price adjustment. In each of these three instances, projections were developed for 1980 and 1985 on an informal basis using paper and pencil or desk calculators and drawing on a wide variety of data and sources of information These "man-made" projections become inputs into the computerized components of the model. Tables 2, 3 and 4 contain some of the man-made projections with respect to yields, resource allocations and prices.

Specific components developed to help prepare the projections for the sector analysis include:

1. Sub-components of the agricultural production model: annual crop production, perennial crop production, and livestock production (rudimentary version). The annual and perennial crop sub-component

compute for three regions and 12 agricultural commodities; output, supply, farm consumption, income, costs, returns to land and labor, and seasonal labor requirements. The rudimentary livestock sub-component computes output and value added for each of 6 livestock commodities.

2. An urban demand model which computes nonfarm consumer demands for 19 agriculturally-based commodities and one aggregate non-food commodity as a function of price, income, and population.

3. A population model which projects the rural farm population and the urban nonfarm population as a function of time-dependent birthrates, death rates, and migration rates.

4. A dynamic national input/output model which projects urban non-farm Gross National Product (GNP) and income.

Certain mechanisms for adjusting prices, allocating areas to different crops, and adjusting yields have not yet been programmed to link the components outlined above. (These mechanisms are enclosed by dotted lines in Figure 4). Therefore, in making the current projections on the computer, it was necessary to use a "manual" iterative procedure to adjust yields, crop areas, and prices in order to equate production with consumption and to bring exports and imports into line with current levels and reasonable projections for the future under various alternatives.

As a result of this iterative procedure, projections of the following (and other) variables are produced for 1975, 1980 and 1985 for the several policy alternatives: farm output, consumption, farm income, farm income per capita, farm consumed calories and protein per capita, returns to land and labor, value added from agriculture, urban consumption by commodity, urban price indices, ratio of urban food expenditure to total urban expenditure, and imports and exports by commodity.

Figure 4 is an oversimplified version of several hundred equations which express the relationships being modeled in quantitative form for computing purposes.

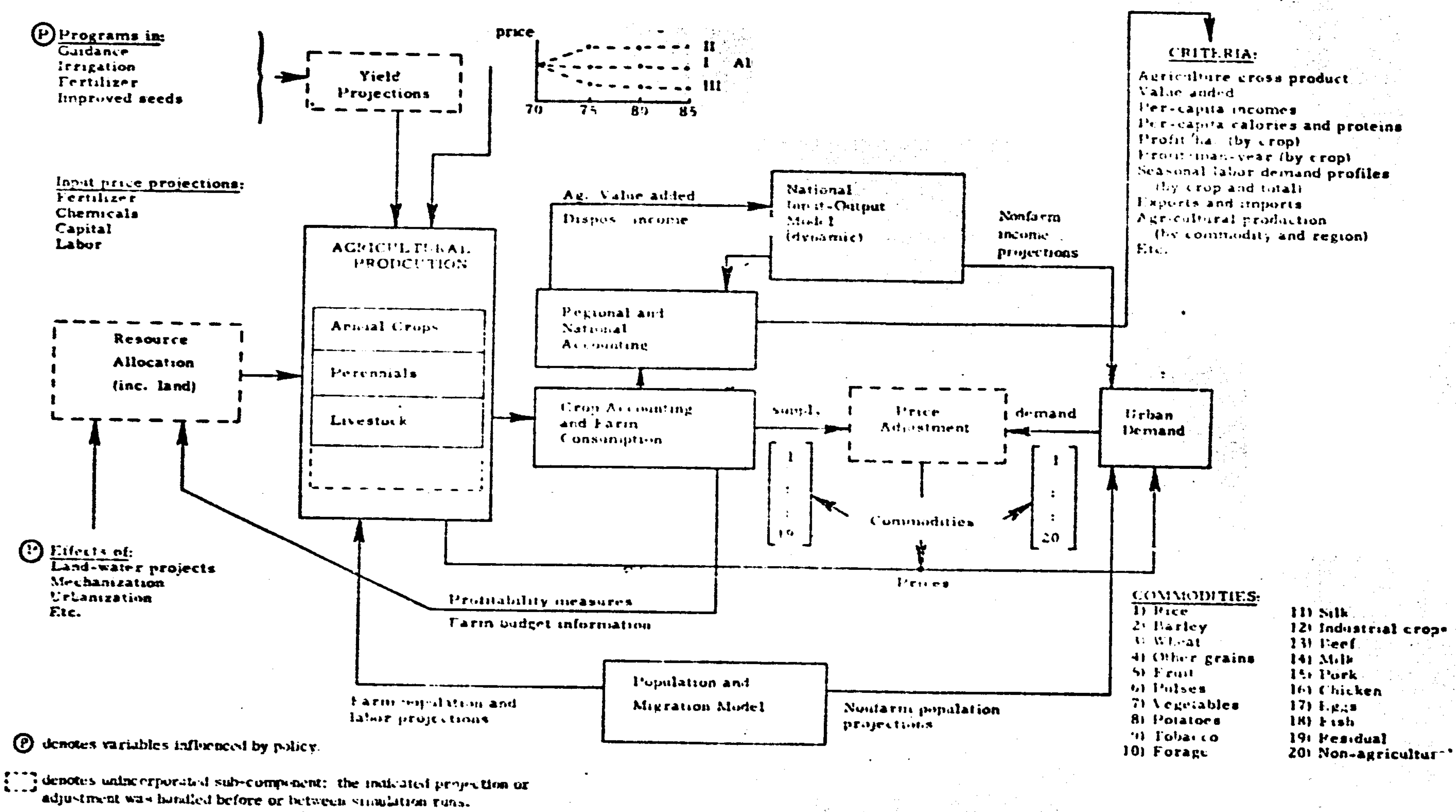

FIGURE 4. Diagram of iterative operational model of Korean agricultural sector actually used to project consequences of alternative policy strategies.

Development of KASS Model

Korean administrators are seeking so many different goods and avoiding so many different bads in developing their agriculture that it is very difficult for them or anyone to find a common denominator for a maximizing model. Consider, for instance, the goods of (1) adequate food, (2) political stability, (3) off-farm migrants to develop industry, and (4) education. Also consider the bads of (1) unequal incomes between farm and urban people, (2) dependence on food imports, (3) water and air pollution, (4) urban slums, (5) destructive revolution, (6) malnutrition, (7) illiteracy, etc. Who can determine, before analysis, a common denominator among such divergent goods and bads? And how can one be sure that the damages imposed on some by unequal agricultural growth are greater or lesser than benefits conferred on others? Who can know ahead of time the best order in which to execute the projects within a program, and the programs within a policy? And, if knowledge is uncertain, how can one know whether decision making should be cautious or chance taking?

Because of such complex questions, the KASS team preferred, initially at least, to use general models to project the consequences of following alternative courses of action--in terms of several goods attained and bads incurred. In Figure 3, these variables are indicated in the lower right hand corner as performance variables and in Figure 4, as criteria. The KASS group views itself as assisting public decision makers by (1) making projections of such variables available, and (2) helping to reach prescriptive decisions as to the right actio[n] to take concerning policies and programs. The KASS approach is general with respect to the use or nonuse of maximizing models.

It is also general with respect to sources of data and techniques, as it accepts data and information from many sources, that is, time series, carefully controlled experiments, the normative and non-normative judgments of informed men, survey data, and opinions, etc.

The KASS approach is designed to trace the consequences of alternative courses of action through time. Therefore, it can be viewed as capable of simulating the performance of Korean agriculture under Alternative Policy Strategy sets. It is this ability to trace consequences through time which makes it a simulation approach. Simple planning and budgeting models employed long before the existence of even simple mechanical desk calculators were simulation approaches. Historically, such approaches atttained and maintained high credibility among both public and private decision makers. It is a mistake to assume that only a computerized approach can be a simulation approach and that all simulation models are computerized. To do so is to ignore some of the most effective simulation work done and most of the actual basis for private and public decision making.

The model was constructed so that it could be computerized. Personnel, time and costs can be reduced several fold by using electronic computers.[1/] The KASS model is also a systems model in which the Korean agricultural sector is viewed as a system made up of sub-systems, and which is itself a sub-system of a still larger system, the national economy of Korea. Fortunately, the Korean national economy is modeled in a general way so that the more detailed KASS agricultural model can relate agriculture to the rest of the economy. When and if a general systems simulation model of the nonagricultural sector of Korea is developed in the detail being created for agriculture, it will be easier to study more fully the farm/nonfarm interactions for the entire Korean economy.

[1/] Glenn L. Johnson, O. J. Scoville, George K. Dike, and Carl K. Eicher, Strategies and Recommendations for Nigerian Rural Development, 1969/1985, review by Peter Kilby, American Journal of Agricultural Economics, 53: 375-376, May, 1971; and Glenn L. Johnson, "Peter Kilby's Review of Strategies and Recommendations for Nigerian Rural Development, 1969/1985," Am. J. Agr. Econ. 53: 678, November, 1971