Food Distribution Research Approaches for The 1970's

Systems Analysis in the Food Industries

Food 70's

The author describes the principal methods of systems study used or possible for Food Distribution

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> There are more things in heaven and earth, Horatio, than are dreamt of in your philosophy.
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> Hamlet, Act I, Scene 5.

It is unlikely that Hamlet was thinking of systems analysis when he gave his famous dictum to Horatio, but it seems to me an appropriate comment on your speaker's dilemma this morning. Systems analysis is all things to all men, including being a black box to many. This morning we will attempt to shine a candle briefly inside the black box to illuminate at least some of the compartments within it.

Put most concisely, systems analysis is simply an analytical approach to the system of doing something. We can talk about the analysis of systems of corn production or meat distribution or any other function in the production and marketing chain. Or we can talk about the entire production and marketing system for a given product, for food or, at least conceptually, for all goods and services. Systems analysis means simply that we will use some kind of quantitative technique to analyze whatever system we have selected.

The quantitative techniques most often used in systems analysis are generally called simulation. 1/ For our purposes, there are three general types of systems analysis.

Engineering or Biological Systems

The first general type of systems analysis refers to the simulation of engineering or biological systems. 2/ In such an analysis, one tries to reproduce in a set of mathematical equations the technological or biological relationships in

1/ See G. H. Orcutt, "Simulation of Economic Systems," Amer. Econ. Rev., 50: 893-909, 1960; R. E. Suttor and R. J. Crom, "Computer Models and Simulation," Jour. Farm Econ., 46:5:1341-1350, Dec. 1964; and Martin Shubik, "Simulation of the Industry and the Firm," Amer. Econ. Rev., 50:908-919, 1960.
2/ See T. S. Ronningen, "Systems Research in Agriculture," Agric. Science Rev., 6:4, pp. 1-6, Fourth Qtr. 1968, and Report of Proceedings. Forage Research Planning Conf., U.S. Meat Animal Res. Ctr., Clay Center, Nebr., June 30-July 1, 1969, 8 pp.

some particular system. One could, for example, construct such a simulator for a warehousing operation or a packaging operation. Since such a system deals strictly in physical terms, it is less likely to be of interest to the members of this Society than some other types.

In many analytical problems, one or more relationships are not known with certainty, but only on a probability basis. The best examples are those dealing with states of nature such as weather and biological phenomena.[3/] For example, if one were analyzing a crop production system, he could represent the likelihood of the occurrence of different kinds of weather by a probability distribution. This would permit the analysis of the results of different types of crop production systems under varying weather conditions. Thus, one might find that the "best" haying system would be quite different in an area of frequent small rainfalls than in one where rain occurred only at long intervals. Similarly, the incidence of disease could be taken onto account in an animal production program. Monte Carlo methods and Bayesian statistics permit the analysis of these types of situations and others where probability distributions are the rule rather than certainty.

Least - Cost Systems

One major type of systems analysis of interest to those engaged in food distribution research is that of least-cost or optimal systems. For many years we have been engaged in research to determine the lowest-cost ways of performing specific functions. Economists, industrial engineers, and others interested in the field have investigated the costs of, say, packing apples or freezing green beans by various methods to determine which one represented the lowest-cost levels. Until recently, most such work was done by economic-engineering methods, by which one determines the physical inputs required to perform a specific job and costs them out at standard wage rates and input prices. Since the mid-fifties, an increasing amount of such work has been done by linear programming techniques which perform the required calculations much more rapidly than the simpler budgeting methods and make it possible to consider a much wider range of alternatives. More recently, other programming techniques have become available which allow one to deal with other than linear forms.

Using linear programming or one of the related techniques, one can determine the least-cost combination of methods of performing each of the functions in the production and marketing chain, subject to a wide range of constraints at each level. These techniques have also made it possible to deal with spatial problems in which we can determine the least-cost distribution scheme over any geographic area, either for fixed supplies and fixed demands at each

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3/ Perhaps the best-known example is Orcutt's demographic model: G. H. Orcutt, et al, Micro-Analysis of Socio-Economic Systems: A Simulation Study, New York: Harper, 1961.

point or with functional forms of supply and demand relationships. This is a well-known field of research and I presume well understood by all those in attendance here.

The usual conditions for the successful conduct of research in the economic world apply. The results will only be as useful as the accuracy of the coefficients used and the assumptions made in building the model.

Behavioral Systems

When we talk about behavioral systems, as compared with the types of systems previously discussed, we mean a system which includes behavioral relationships between the key parts. We are talking about an economic system where we try to represent what people actually do, rather than some ideal system such as that which minimizes costs or physical energy expended or one which assumes that people respond only to prices and costs. Such a system does not pretend to involve psychoanalysis of the participants to determine why they do whatever is that they do. It intends merely to represent what people actually do in relationship to observable characteristics and situations.

This type of systems analysis typically utilizes simulation techniques in which one develops a recursive model over some historical period and attempts to simulate the performance of a set of variables over that time period. In a recursive model, the results in any given time period depend upon those in the preceding period and the functional relationships. The test of this kind of model is the success with which it can be validated over the historical period. The usefulness of such a model is in projecting into the future the results which can be obtained of various assumed changes in key parts of the model.

We can distinguish at least three kinds of behavioral models, depending on the level of aggregation involved.

Macro Models

In a macro model of a behavioral system, we deal with all production, processing, distribution or consumption in the aggregate and derive functional relationships between them. In general, such a system is similar to the supply-demand-price models with which we are familiar, but the method of determining the relationships is different from that customarily employed in econometric models.[4/] The advantage of simulation over conventional models is that a dynamic model can be much more complex and realistic.

Micro Models

A mirco model attempts to simulate the behavior of individual firms at each level of the production and marketing system. It is obviously impossible

4/ For example, W. R. Maki and R. J. Crom, Evaluation of Market Organizations in a Simulated Livestock-Meat Economy, Iowa Agr. & Home Econ. Expt. Sta., Res. Bul. 541, Oct. 1965, pp. 579-623.

to construct one to simulate an entire system, since the amount of detail required would far exceed the capacity of the computer or of the analyst. A substantial number of business games have been constructed which deal with the operation of some sub-system. In a business game, many of the functional relationships are not specified in the model but rely on the decisions of the participants in the game.

Representative Firm Models

These models are intermediate between the macro and the micro models in terms of level of aggregation. They break down the participants at any level of the system into several major types, each of which has a different decision function. In the short run, each representative firm reacts to existing and expected prices, costs, demands or supplies within a fairly restrictive set of restraints, including its existing capacity to produce product or services, and institutional restraints. In the long run, each representative firm has the capacity to grow or decline, depending on potential profits, availability of capital, level of management ability and the potential to change it, and other resource restraints.

To our knowledge, such a model has never been constructed, although some beginning efforts have been made. It seems quite likely that ERS in cooperation with several Corn Belt experiment stations will attempt to build such a model of the hog-pork industry. By explicitly considering both the short-term decision variables and the long-run growth variables, such a model would go a long way toward providing the kind of insights we have never been able to successfully obtain by modeling techniques in the past.