LEONTIEF INPUT-OUTPUT TECHNIQUE AND THE DEVELOPMENT OF AGRICULTURAL DATA SYSTEMS

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Introduction

This paper suggests that a Leontief type input-output technique has an unrealized potential as the basis for efficient data systems. A model in the process of development for the UK livestock, meat, and meat products industry is used as an example. An expansive discussion of agricultural data systems is beyond the scope of this paper, but a thorough examination of the principal issues and an extensive bibliography are given by Barnard.

The Contribution of Leontief Input-Output Technique: A Case Study

Origins

The Meat and Livestock Commission in the United Kingdom requested a "network analysis" of the entire UK livestock and meat industry, the origins of which are described by Duckworth. Briefly, since the Commission is charged with increasing industrial efficiency, it was felt essential to obtain a detailed description of the industry's economic structure. In this context, "increasing efficiency" is broadly defined as providing the environment wherein economic objectives can be more easily achieved. From an awareness of areas where information is limited, research effort can be directed to increase the level of knowledge. In turn, this knowledge should assist in guiding policy decisions.

Requirements

A "network analysis" implies the need to account for the salient features of the industry and particularly the interrelationships between economic activities. The industry which the Commission serves demands that expression of interrelated features must include information significant to a wide range of personnel. For example, within the Commission there are specialist divisions and services concerned with a mix of both economic and technical data. Clearly, these two aspects are not independent, but they do set the extremes.

The need for a data system for the livestock and meat industry is evident. Since the data are explicitly problem oriented for the reasons described, it may be preferable to speak of an information system as distinct from a data system. Eisgruber appears to favour the distinction, regarding data as messages which are unevaluated for a particular use at a particular time. Once associated with a problem, the data become information. The distinction is more attractive in principle than practice, however. The term "data system" is retained here, although the distinction between data and information is sometimes useful.

The data system should be easily understood because of the variety of users. Physical and value data for the demand and supply of all inputs and outputs, and the interrelationships between enterprises, products, supply, and demand must be shown in an uncomplicated manner. The importance of minimizing technicalities when economists are providing data to nonspecialist policymakers is emphasized by Capstick.

Conceptual Framework

It is implicit that the data system requires a simple yet comprehensive model of the industry. The extent of the sector suggested that a systems approach would be helpful. The ideas developed subsequently have much in common with the frameworks developed by French and Nieto-Ostolaza. The livestock and meat industry is essentially a system bounded on the one hand by industries generating inputs used by farmers, animal product processors, and distributors, and on the other hand by exogenous final demand determinants. The system comprises four subsystems representing pig, poultry, beef, and sheep products at all stages of production, processing, and distribution. These subsystems can be disaggregated into first stage production (farm production) and second stage production (processing and distribution). Furthermore, these two stages contain conceptually distinct activities such as rearing systems for livestock, and distributive networks for products as between, say, household and catering consumption, small goods manufacturing, and exports. These characteristics will be reflected in the structure of the data system.

The stringency of the requirements precludes any complex mathematical systems model. However, the link between the systems model and the data system can be established by assuming that the flows of outputs and resources throughout the total system are described by linear functions. A review of the possible methods for formalizing the industry model pointed directly to a Leontief input-output framework.

Advantages of the Input-Output Approach

The Leontief input-output technique is a type of programming model. Petit aptly summarizes the attraction of such models in that they "are very efficient instruments to organize coherently a huge mass of information; the very specificity and explicit character of the assumptions on which they are based lead to their thorough discussion--a definite advantage."

The application of instructions to elementary data (that is, physical coefficients and unit values) for each product sector generates the corresponding transactions submatrices. Within each product sector matrix is described the nucleus of the subsystem in the form of intermediate transactions, with primary inputs as inflows and final demand as outflows. Interaction between the subsystems is described by aggregation into the industry matrix. It is through this initial manipulation of data that fundamental gaps in knowledge become apparent. For example, it was quickly found in constructing the beef sector matrix that store cattle movements and the relative importance of rearing and fattening systems are poorly documented. Data gaps become apparent from simple description and the importance of filling them may be assessed via sensitivity tests at this stage, but other facets of the input-output technique also contribute.

In the input-output technique, a distinction is often drawn between its uses for description and analysis. The explanation above shows that even simple description has an analytical function. The more usual analytical applications are for economic planning, impact analysis, optimization of some objective function, study of price effects and the comparision of policies. These applications are clearly explained in O'Connor and Henry, and their relevance in the present context is discussed with extensions by me (Howe). The vital point is that the structure of the basic matrix showing total resource flow and the technical coefficients from it are easy to understand. Even the principles of obtaining the interdependence coefficients do not require a profound knowledge of matrix algebra (see O'Conner and Henry). Most important is that the whole exercise focuses attention on the basic data inputs and how these are used.

If it is thought that there may be errors in assumptions about the existence and magnitude of intraindustry flows, then the structure of transactions can be changed to simulate different possibilities. Armed with any new transactions matrix, the subsequent computations are carried out as usual and results similarly appraised.

Organization and Administration of the Data System

A number of facilities are envisaged, each intended to contribute to the desirable qualities of modern data systems outlined above. At the present developmental phase, the model is being explained on index cards, with two sets for each of the total system and its four subsystems. One set explains the calculations and the other sources of data. Cross referencing enables sequential calculations to be traced and matched with data inputs. It is anticipated that adoption of the data system will be accompanied by transfer of these records to computer files. A possible generalized structure is shown in figures 1 and 2. The flow diagrams are largely self-explanatory, but some supplementary explanation is needed.

The "read year" command in figure 1 shows that the data system is geared to recording and manipulating time series information. If desired, users may call lists of instructions, data, and sources. These are essential facilities because improvements can materialize only from scrutiny by authorized and informed parties. Alternatively, data or sources listings may be extracted by researchers who wish speedy access to information for their own purposes.

Figure 2 continues figure 1 and shows the options for producing matrices and manipulating these for both the industry and its subsectors. Both data and instructions may be altered, and the consequences investigated on recomputing. The changes may well require new matrix dimensions. The broken box for sensitivity tests and comparative options is so presented because it includes a range of possible subroutines. For example, it may be useful to compute measures of variance for matrix coefficients calculated from different data sets under different assumptions.

Conclusions

It is contended that the application of a Leontief input-output technique to the problem of establishing data systems meets many of the objectives identified in appraisal of the existing situation. The UK meat industry model provides examples.

First, the model is avowedly oriented towards the enduring problems of understanding the fundamental structure of the industry and monitoring developments over time. Second, the model is holistic in that it encompasses the entire industry. Traditional preoccupation with obtaining farm production data has hindered documentation of the processing sectors, but the data gaps are defined and improvements can be initiated. Third, a particular strength of the model is that it is explicitly constructed from elementary data on unit prices, costs, and physical coefficients. This maximizes flexibility in the data system as circumstances and data requirements change. Moreover, matrix entries can be altered to simulate changes in economic structure and technical coefficients. Contrast this property with the accounting framework of Carlin and Handy, an improved though nevertheless rigid structure which may itself be rapidly outdated. An input-output model could be used to set up data in a corresponding form. It is interesting that, in common with other accounts of data systems, Carlin and Handy employ a variation of the input-output approach.

More generally, the input-output technique has potential as the basis of a much wider data network. In the United Kingdom, a network can be envisaged in which the Department of Agriculture and other organizations including, say, the Meat and Livestock Commission, the Milk Marketing Boards, and the Home Grown Cereals Authority establish and integrate compatible data systems. In principle, the apex of the integrated network would be a transactions matrix for the national agricultural industry. Decentralization meets the objective of exploiting particular areas of expertise.

The inherent assumptions of linearity may be considered a limitation, but extravagant claims are not being made for the technique. If construction of more flexible models is appropriate for certain aggregate or subsector problems, there is nothing to prevent it. On the contrary, the data system provides the optimal route to relevant information.

The mere development of a single industry model must necessarily have a long gestation period. In the longer term, the demands on resources will be high, but results of the kind produced by Hayami and Peterson indicate the considerable benefits which can accrue. The potential contribution of the Leontief technique appears to have been overlooked. It is considered that the method warrants serious discussion and investigation in other sectors of agriculture and in other countries.

Figure 1 Basic facilities provided by the data system

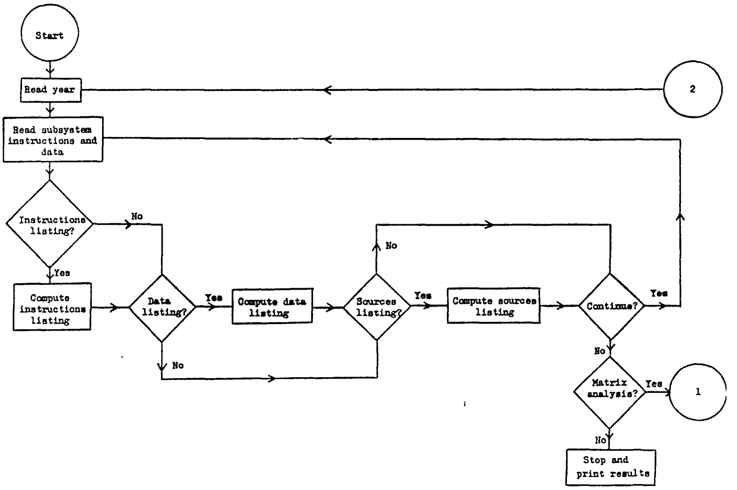
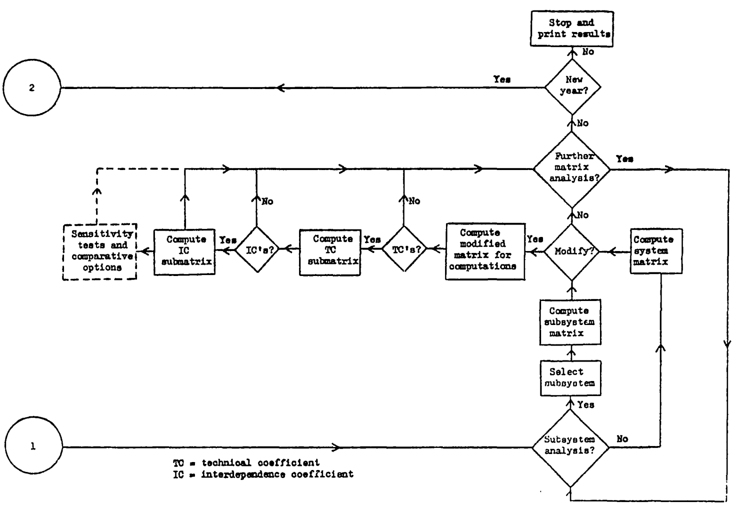


Figure 2 Computation and manipulation of matrices.



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RAPPORTEUR'S REPORT--Andre Brun

Howe's model can effectively be taken as a data system. Its input-output nature, in aggregate terms, makes it possible to describe activities, but not to explain production decisions. As Howe argued, it can be progressively disaggregated with the help of more accurate data, when its utility is recognized. For instance, the lowland steppe activity could be subdivided to account for different products such as wool and meat; but, it is clear that to attempt to achieve a once and for all universal and detailed collection of data is impossible and would be a waste of time. The author emphasizes the possible use of this kind of model, through the interdependence coefficients, to investigate the perturbations caused by a change in any input or output. The fact that he has been driving the model by the output (demand) does not imply that he cannot proceed by the input side.

The need for exploring the meaning of the input-output coefficient by clarifying the structure of any subbranch and the technologic spectrum is recognized; but this kind of test has not been implemented. The validation of the input-output coefficient remains a must whatever the kind of test.

Contributing to the discussion were Denis K. Britton, Wilhelm Henrichsmeyer, John O. S. Kennedy, and Alfred Thieme.