IMPLICATIONS OF PROSPECTIVE STRUCTURAL CHANGES IN FARMING FOR THE USE OF DATA PROCESSING

by Buel F. Lanpher* and Robert M. Finley**

Electronic data processing (EDP) has become a definite part of our economic life. Business Week estimates that $4 billion will be spent on computers and EDP systems this year and no signs of slowdown are indicated. Not too long ago a comment was observed in a newspaper editorial that went something like this: "At the rate computers are being adapted, we can visualize in the not too distant future, junk yards of obsolete computers the same as we now have unsightly junk yards of old and obsolete automobiles." This comment, although intended to be somewhat facetious, however, is reinforced by the fact that the first UNIVAC was recently placed in the Smithsonian Institute as an antique.

In this paper the following assumptions are made concerning future developments in EDP technology:

1. There will be a continued and probably accelerated development of new electronic data processing hardware and processing techniques. The developments should greatly improve or provide new and better ways of manipulating data and transmitting data from source to processing facilities.

2. There will be a steady improvement of methods and techniques for facilitating communication between users and EDP facilities.

3. There will be a continuing reduction in the cost of data processing, particularly on the per unit of work basis. Also, it is assumed that initial overhead investment required to own or rent comparable amounts of processing capacities will continue to be reduced.

4. There will be widespread increase in the knowledge of EDP and its effective use by both farmers and the general public.

Any forecasts or estimates of the use of future EDP services in agriculture obviously becomes a hazardous pursuit. Nonetheless a greatly increases use of EDP in agriculture over the next 10 to 15 years appears to be a foregone conclusion. However, further growth in the effective use of EDP in agriculture will not come without forward planning and organization.

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From experience up to present we know that it takes trial and error, experimentation, and continuous perfecting of techniques. We know, too, that much training, knowledge, and judgment are required on the part of both the managers of agricultural firms and professional personnel involved in using EDP. However, compared to future developments the present stage of EDP use in agriculture may turn out to be as primitive as the very earliest of the Model T Ford was in comparison to the present-day Cadillac.

The advent of EDP technology -- along with simultaneous structural changes which are placing greater emphasis on management inputs -- offers a unique opportunity to the agricultural colleges in the country. (This might also be considered a responsibility.) It is well acknowledged that our agricultural colleges and the USDA have contributed immensely to the development and understanding of production technology in agriculture. Colleges have considered production technology to be their responsibility; they have taken active leadership; and they have gained tremendous public respect for their research and extension activities in this field.

However, this situation does not seem so clearly to exist in regard to management technology. But in the period ahead will the agricultural colleges and the USDA play the same role in regard to developing, testing, and implementing management technology in agriculture? With the past and prospective changes in agriculture, these public institutions well may find their main opportunity to contribute to agriculture and to the general economic progress of the nation through serving a leading role in management technology. Yet the colleges seem to be laggard in their responsibility and opportunity to point out the management revolution in agriculture and to assess potential of new managerial tools for farmers.

Current Uses

A major current use of EDP as an applied management tool in agriculture is in record keeping projects. Farm records are being processed in cooperation with college-operated projects at 15 locations around the country. Some of the processing locations are regional or multi-state operations. It is estimated that 35 state colleges are processing their farm records through one of these 15 EDP facilities. In addition, some colleges are also using EDP to analyze records kept with the traditional record book.

Over the years various techniques have been developed which utilize EDP for studying ways to improve farm management decision making. Of the techniques most used, linear programming has been outstanding. Many variations of programming have been developed to handle different types of questions and problems that have arisen.¹

¹Some shortcomings of mathematical programming have been solved or will be solved in the near future. Two common criticisms of the use of linear programming have been the linearity and divisibility assumptions. However, routines for integer and concave programming are now in practical use. As we use these "refined" programs, we may perhaps conclude that the non-integer and linear aspects of the older routines were not as inhibiting as once thought, but merely served to take focus off of some still unsolved problems.
Almost all the states have programmed a single farm situation here and there but only a few have worked directly with farmers in implementing farm reorganizations called for by solutions. One of the largest-scale operations to date is the Rapid Adjustment Program cooperatively sponsored by TVA and the colleges in the TVA region.

Likewise, in some instances, linear programming has been used to obtain least-cost or minimum-cost solutions. This aspect of linear programming is especially appropriate for many farm and agri-business problems. Managers of large-scale cattle feeding operations are much interested in this technique, and the Extension people at Texas A & M are specifically testing some least-cost rations with some feedlot operators in west Texas. Other examples of practical application by colleges of least-cost linear programming include work with poultry operations in the east in formulating minimum-cost rations and fertilizer plants in the midwest in determining least-cost specification fertilizer mixes. It is well known that various agri-business firms, such as feed companies and meat processors, are using linear programming to obtain least-cost blends.

Future Possibilities

Some possibilities for the near future are obvious for perfecting record processing and improving their usefulness. Increasing the promptness of return of record data is one avenue for improving the decision-making potential of records. This depends, however, on the farmer's promptness in reporting and having the processing system well organized. With present and prospective processing equipment it is possible to manipulate record data so that many different kinds of analyses could be prepared that were not within the realm of practicability in the past. Also, as the numbers of cooperating farmers increase it becomes possible to have more homogeneous groupings of farms in analysis reports. As farm size increases and farms become more specialized the homogeneous grouping becomes increasingly more important, especially with respect to resource and enterprise comparisons.

Such homogeneity would greatly improve the value of record analysis to the individual farmer for analyzing for possible adjustments. It would enable more relevant cost comparisons between farms on an intra-regional and inter-regional basis. Great advantages could be foreseen in having local and regional enterprise cost data available to the individual farmer to guide in operational cost control and long-run investment decisions. For example, prompt information on detailed production and marketing costs in poultry and beef feeding operations for competing locations would be most valuable to producers as well as the agri-business and marketing firms involved.

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\[\text{For example, I. Katzman "Solving Feed Problems Through Linear Programming" Journal of Farm Economics, May 1956 or Robert M. Finley et al "Minimum Cost Mixing for a Bulk Blending Fertilizer Plant" Station Bulletin 466, Nebraska Agricultural Experiment Station in cooperation with TVA, Octover 1961.}\]
We have long had dreams of enterprise cost data being derived from farm record projects. However, these generally have not materialized. There appears to be a new hope that with EDP record systems we can obtain enterprise cost data from at least a relevant fraction of farm firms. In fact, several states are attempting to incorporate the enterprise cost studies with their farm financial records.

However, many farmers do not do this, and they may continue to feel that it is not worth the effort to record data by enterprises or sub-enterprises or lots within an enterprise. This is probably a correct decision for a considerable number of farms as currently operated. However, an increasing number of farm managers are finding this a worthwhile activity. Also, as large farms engage specialized personnel or accountants to help them in record keeping, it becomes more feasible to record data on a highly detailed enterprise basis.

A standard coding system for the United States would be another important method improving the usefulness of EDP record programs. Such a comprehensive coding system would be a real advantage to all those who make use of farm record data. With a standard code, many comparisons not now possible would be available. For example, types of farming could be easily compared. Many state lines are merely political lines and do not conform with type of farming areas, and often farms of the same type although located 1,000 or more miles apart are more similar than farms across the road. If all states used the same coding system then the extension and/or research worker could combine samples from several states and a more meaningful analysis would be forthcoming. Furthermore, communication among workers in different states and perhaps even different disciplines would increase. Warren Vincent in 1963 explained such a system in a scholarly article "A Proposed Coding System for Agricultural Research and Service Projects."\(^4\) Vincent has subsequently developed a proposed national code in connection with a project for the Federal Extension Service.

As we learn more about the intricacies of data storage and retrieval, some problems associated with heterogeneous coding systems will be overcome. The coding systems used by, say, Texas, Missouri, and Colorado could be read into storage, and if only coding numbers are different, then comparisons and analysis could be made almost as quickly as if a standard coding were in use. Inadequacies of the above would be apparent when not only coding is different, but when various code items are combined in one system and not others, or when code items are subdivided for one system and not others.

What are future prospects that any substantial use will be made by farms of linear programming and other decision-making techniques using EDP? There appears to be little question but that a high percentage of farmers would initially receive relatively large returns from an initial series of programming solutions. However, after a farmer has had one initial solution how soon will he be interested in another solution? Many farmers would be logically interested in an occasional recheck of optimum solutions from time to time.

The advent of a new production technology, availability of new resources, or a change in the enterprise interest of the farmer could precipitate his seeking a new linear programming solution.

However, the frequency that complete re-programming might be worthwhile will be limited to the type of farming and the resources the farmer can employ. Then such non-EDP techniques as partial budgeting, simplified programming, and block budgeting may be more appropriate. There is much agreement that future prospects for applied use of linear programming will hinge upon the growth of understanding by farmers of these techniques and the availability of reasonably usable data for individual farms. From present observations of farmer's reactions to linear programming, farmers are much more interested and willing to use the technique than many professional farm management people anticipate. There seems to be a tendency by some economists to regard programming as almost as strictly a research technique and exhibit little imagination regarding its use in actual on-farm planning and decision-making. It appears that farmers do not need to know or do they want to know the complexities of the computing process. Generally, the farmer only indicates the choice of enterprise and coefficients of the program format; he has faith in the computational process. He is far more interested and concerned about the implementation of the resulting solution or solutions.

On the question of obtaining data for linear programming or any other form of budgeting, many believe that more accurate input-output data are required and that individual enterprise farm records are almost essential in order to have usable data. Certainly improved data from research and farm record projects are highly desirable, and we need to consistently work in that direction. However, the individual farmer undoubtedly is willing to accept the best data available as determined by the judgment of the farm management worker and himself. These judgments would, of course, be based upon research data, the farmer's own data and synthesized data adapted to the enterprises under consideration. Detailed enterprise records on an individual farm are desirable and useful, but they do not provide data either (1) on enterprises not now in production on that farm, or (2) on new production technology or production systems which might be considered.

We may have almost completed a full circle in our thinking about the applied use of linear programming. A decade or so ago, the complete programming of many individual farms was thought to be a best use of the technique. Then, later, the philosophy appeared to be that of only programming a few case farms or representative farms which would serve as benchmarks for management recommendations. Now, if we assess the tenor of current thinking correctly, the trend is again toward complete programming of individual farms. This happening results not only from a shift in the thinking of farm management personnel but also from farmers' increased awareness of a need for more precise and complete budgeting. The structural changes projected in this conference indicate a growing uniqueness in the characteristics of the individual farm firms and in the magnitude of their management decisions.
If we cast our thoughts still further ahead we can see far-reaching effects of EDP in agriculture. Even at present, we could store complete farm records on the memory drums of a computer. We already store technique routines in this manner. Even on small computers when a certain routine such as multiple regression or linear programming is needed, a call signal is given through the typewriter or an instruction card and thus a step involved in introducing the routine deck (on tape) is eliminated. As memory storage becomes larger (and cheaper) we can put all entries of a record in memory storage. Thus, the result should not only speed up the operation but also much of the human error attendant with handling of decks or tapes will be eliminated. When a monthly, quarterly, or yearly summary of X farm is needed, an instruction card (tape) is used to recall specific data or measure for this and/or any prior year. Also combining relevant comparative or descriptive data from similar farms would be simplified.

Another innovation in EDP which is on the horizon is voice recording of data. This promises to have impact on our traditional coding and recording methods. We can envisage farmers having a tape or belt and a recorder by which they merely dictate their expenses, receipts, and other data for that day, or week. Then they would mail the tape or belt to the college. Or farmers could call in information directly to the computer for recording and storage.

Furthermore, to facilitate decision-making a basic programming matrix for a farm could be stored in memory. Uses of this are obvious; for example, a farmer could indicate a need for information concerning the purchase of, say, feeder cattle. The profit (or loss) as well as effects on the entire farm organization of such purchases could be quickly evaluated by calling forth the stored program. Another example could be where a farmer wishes to know the effects upon organization and income for this and subsequent years of the purchase of a new farm machine or an additional acreage. Communication could be made with the EDP center where his records and matrix were stored and a range of solutions could be requested. The range of solutions would be used to assess the alternatives using various discount rates, resource situations, weather patterns, prices, etc.

The possibility of simulation models should not be overlooked. Simulation holds promise of becoming an important management tool. An individual farmer might have a simulation model for his farm which would be continually perfected and updated. As more information and relationships of this farm and other competing farms were established they would be incorporated into his model. For example, a vegetable farmer, just prior to planting, could use a simulation model to appraise the consequences of growing certain vegetable crops singularly or in combination.

If forward planning is to become more accurate and hence more useful, our predictive models must be improved. With EDP, great quantities of data can be utilized conveniently and quickly. Hypotheses relating to price-making and weather factors can be tested and compared in far greater number than previously possible. A result should be more sophisticated forecasting models. It must be recognized, however, that we will always be working with historical data; still, certainly the predictions forthcoming should be improved assuming that some normal statistical logic underlies the past performances. With longer range forecasts of economic and weather conditions we may move from conditions of uncertainty towards those of risk.

When more accurate forecasts are possible, not only will farm planning be more accurate, but partial and general equilibrium studies will benefit. For example, for several years Fred Olson has been exploring and experimenting with the possibilities of projected equilibrium for cattle on a monthly or quarterly basis. He has recently formalized a model and presented an outline of such. This technique, which is applicable to other commodities, may hold considerable promise in improving decision-making.

Commodity demand and supply forces will be more accurately depicted and forecasts will enable researchers to delve more rigorously into problems concerning inter-regional competition, industry and firm structural changes, effects of product and/or technology changes, etc. Furthermore, such complex models could be placed in computer memory banks; they could be retrievable and alterable with relative simplicity.

As pointed out in previous papers, specification production of farm goods of standardized quality will appear more dominant in the future. The role of EDP can be important in such endeavors. In fact, EDP is already being used in one state to standardize quality, predict production, and aid in replacement practices of dairy cows. The cows are rated according to individual performance to the rest of the herd and other management information is recorded and summarized; this includes expected performance during the present lactation, breeding information, grain required based on milk records, mastitis tests, and many other management items. It is possible to maintain at low cost the individual card records on, say, each lot of feeder cattle or caged layer. With feeding and marketing coordinated the efficiency of the industry and firm will increase.

Also, in the future the need for expensive specialized machinery will expand. For some, this will be met by ownership of the machines, but for others the most profitable avenue will be to lease or custom hire a specialized machine, which may be idle 90 percent of the year on individual farms. The appropriate model using EDP can aid in making this decision. For

example, the cost of leasing machinery can be compared with the cost of owning machinery (the latter taking into account the alternative opportunities for using his capital resources which a farmer must pass up in order to buy machinery).

Emphasis upon machinery scheduling (matching machinery to farm jobs and evaluating the match for timeliness of operation) as well as machinery selection will receive increased attention of engineers and economists. Arriving at appropriate probabilities of weather conditions and machinery repair will demand continued attention. Some recent efforts along this line are encouraging and are amenable to EDP.

Although we believe that better input-output data and more accurate weather and economic forecasts will be soon forthcoming, what can we do in the meantime? We know usable answers can be obtained with use of the approximated and synthesized data which can be made available. Price and resource mapping have shown that farm organization are often relatively stable. A recent study at the University of Missouri has shown that certain input-output data could vary over wide ranges with but little change in a basic farm organization. However, as the size and complexity of farm businesses increase it may become more useful to have more precise information on production coefficients.

As we progress into extensive use of EDP in agriculture a key question looms concerning the financing of the operations. Some precedence has been established: e.g. in many states farmers pay all or part of the costs involved in the record projects. At present, several states are investigating the possibilities of offering certain EDP operations (primarily linear programming) on a fee basis. The extension service in one state has recently launched a project of this nature and is now receiving fees and computing solutions. A group of county agents are being trained for direct contact with farmers.

Also, some commercial agri-business firms have a growing interest in providing services such as linear programming. Some of these firms seemingly are interested in offering such services without cost to farmers who are regular customers. It is questionable, however, that in the near future the extra volume of supplies sold would furnish enough profit margin to carry the cost of linear programming of each individual farm.


8It is only on the corners of the production function or boundaries of the price (or resource) map that exact knowledge of input-output data is really necessary.
But for all the potential of EDP in agriculture, perhaps we overlook the most critical issue of all. Charles Beer$^9$ has pointed out that "high speed computers may enable a group of progressive managers to bring about change more rapidly than society as a whole is ready to accept this change." Supporting this statement he indicates that large-scale operators are in a better position to take advantage of knowledge.

There is always a problem in becoming computer oriented rather than problem oriented in our research. We do need to know something about computers, the extent of which is an unsettled question. Ludwig Eisgruber$^10$ has summarized the role of computers as follows: "... the researcher is challenged to examine carefully (a) whether certain computer applications enhance or impair his productivity, (b) which problems can be analyzed more effectively if the electronic tool is used, (c) which problems can be analyzed only if computers are used, (d) which organizational changes are needed because of the possibility of electronic computer application and (e) what skills are needed for effective work in computer utilizing research."

Use of computers should not allow us to become careless about model formation. As previously indicated there is always a temptation to become computer-oriented. In other words rather than the researcher determining the model with its attendant variables we may be tempted to "load up" the computer with all conceivable variables and let it sort out the relevant ones. While this approach has a certain appeal, it generally should be avoided. There will always be a degree of arbitrariness involved in variable selection, but this should be the domain of the researcher.

Summary

More information is now available for decision-making than at any other time in history. The basic problem is to organize such information into usable and meaningful framework in order to facilitate use. With advances in data processing we can foresee important possibilities for achieving more accurate and definitive farm planning. Mere faster and better methods of data manipulation do not transform inadequate data into adequate data. But EDP methods allow the more thorough testing of both hypotheses and data. Too often the gathering and organization of data have been considered the duty and responsibility of extension. Researchers must take a stronger cooperative role in data development if more meaningful analyses are to be forthcoming.
