REVIEW OF MARKETING AND AGRICULTURAL ECONOMICS
VOL. 47, No. 1 (*April*; 1979)

On The Development and Use of Automated Management Aids

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The last twenty years have seen the development of many techniques designed to provide management information. Despite this, comparative budgeting is still the most commonly used analytical technique in applied farm management. There are moves, however, to change this situation through the development of systems designed to enable management aids to be readily available. These systems usually rely on the use of a computer. In this paper the current situation is reviewed by outlining system categories that have been developed and through discussing the important questions in the successful development and use of automated management aids designed for farmer use.

1 Introduction

An "automated management aid" is defined as any system using standard operations which is designed to provide a farmer with information useful for decision making. Usually, automated systems require an electronic computer for implementation but this is not always necessary. A budgeting routine, for example, can be performed on a regular basis by clerks where farmers mail in the basic data on prepared input forms.[1] Automated systems have been used for a number of years throughout the world but only recently has there been a major growth in their development and use. The purpose of this discussion is to review the use and abuse of automated aids. Earlier reviews have been given by Candler *et al* [3] and Eisgruber [5].

Automated systems have been developed for at least two reasons. One is that some decision making aids cannot realistically be used without the use of an electronic computer. An example is linear programming. The other is that many management aids, ranging from simple budgeting through to complex investment models, simply have not been used by extension people due in part to the work involved and the understanding required. Automated systems can enable extension workers, and farmers, to use all these aids with a minimum of personal work input. Of course, it is possible that "sophisticated" aids have not been used as they do not provide satisfactory answers to the problems. Musgrave [13] implies this when he states that "very few of the techniques and concepts of the management theoreticians have found an enduring place in the tool kit of the practitioner". However, a reliable judgment cannot be made until it is in fact possible for the techniques to be easily applied through the use of automation. This discussion does not contain any comments on the inherent realism of the various management aids or decision models. Rather, the emphasis is on the question of making aids available for more general use by extension people and farmers.

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1. The Meat and Livestock Commission in England operate a hand worked cash flow prediction budget for use by pig farmers. Standard input forms are filled in and the data is used in a series of standard calculations.

Automated aids were probably first introduced through accounting and recording schemes. In 1957 a group at Michigan State University were considering the idea of developing automated schemes [5], though there were a number of informal schemes developed before this. However, it was not until many years later, largely through the stimulus of electronic computer availability, that more sophisticated schemes were developed. Around 1968 the idea of bringing linear programming to farmers was conceived. Th resulted in the MASCOT system in England[2] and the "B" series of models in the U.S.[3] Since then systems enabling a whole range of models to be easily accessible have been developed [8]. This discussion will consider the general types of models that have been developed into generally available management aids, some of the potential uses and abuses of the systems, the requirements for a system to be successful and the possible costs involved. Finally, some comments on where future developments should lie are given.

2 Types of Systems Used

The range of systems currently in operation throughout the English speaking world is extensive [8]. The following list gives *examples* of each type.

(i) Records of historical physical information. Example: the recording of eggs produced and feed consumed and the use of this information for comparison with standards. (Lincoln College, N.Z., operate this scheme.)

(ii) Records of historical financial information. There are many accounting schemes falling in this category. A well known example is the system operated by CANFARM but many others exist, particularly in Australia and the U.S.A.

(iii) Forecasts of physical outcomes for a particular whole farm system. Example: a system for forecasting weekly farrowings, weanings, purchases, sales, culling and so on for pig farms (Meat and Livestock Commission, U.K.).

(iv) Forecast budgets of whole farm financial outcomes on monthly and yearly bases. For example, a system which predicts financial outcomes for pig farmers who have proposed a particular five year development programme (Purdue University, U.S.A.).

(v) Combination recording-forecasting schemes. These schemes are usually aimed at providing a physical and financial control system. An example is the monthly cash forecast and recording scheme operated by the feed firm BOCM-Silcocks in the U.K. Actual outcomes are compared with forecasts and major differences are highlighted.

(vi) Specialized physical and financial forecast systems for single enterprises or even enterprise components. Some examples are:

  (a) a system for calculating the required milking shed size to milk a given number of cows in a defined time with a particular labour force. Operated by M.A.F.F. in the U.K.

  (b) The estimation of sheep enterprise gross margins,[4] a system prepared by the Queensland Department of Primary Industry.

2. Developed by I.C.I.
3. Developed at Purdue University [3].
4. *See* Mill, J. S. and J. W. Longworth [12].

(c) The estimation of fertilizer requirements based on soil test results. Many fertilizer firms and other organizations operate these services.

(vii) Planning systems based, usually, on linear programming. These involve both whole farm planning as well as part farm systems. Many least-cost models are also operated. A feature of some of the linear programming based systems is that they are used to estimate the details of a broadly specified farming system (based on a farmers own data). This approach enables farmers to compare, in successive runs of the system, farming systems for which the physical details and financial outcomes have not been worked out. Some examples of specific services offered are:

(a) crop, machinery and labour planning (Purdue University);[5]

(b) retirement plan selection (University of Illinois);[6]

(c) whole farm enterprise selection for any, or in some cases specific, farm types (I.C.I., Billingham); A.B.R.I., N.S.W.; F.M.S.L., W.A.).

(d) least cost dairy and pig ration selection. Many universities and commercial organizations offer least cost services.

(viii) General Information systems. These are designed to provide a range of general management information such as current prices, material requirements to build a specific type of building, the calcium requirements for pregnancy in humans[7] and so on.

Strictly any of the seven system categories described above can be classed as an information system. The major difference is that most of the systems described involve active farmer participation and provide an answer specific to an individual farm. Some systems which provide a mixture of all types of aids are proposed. An example is the FACTS[8] system being implemented by Purdue University. This involves locating an intelligent terminal in each county agent's office through which a range of services can be provided both "on line" to a central machine, and "off line". Some information systems are becoming totally automated. An example is a British dairy farmer's use of a mini-computer to record individual cow information through automatic sensors on the cow and in the milking shed!

It is worth stressing that the specific systems referred to are examples only. Within any one country mentioned there are many more systems available.

Methods of collecting data and presenting the output are equally as varied as the range of systems available. Usually, some form of input sheet is filled in. Output is often in a printed form. Data collection methods range from "mail in" systems[9] entirely reliant on the farmer, to systems using a specialized secretary to collect the information and even to systems using telephone link ups to a central computer. Similarly, output interpretation may depend entirely on the farmer, or, at the other extreme, be carried out by a professional.

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5. *See* McCarl, B. and J. Falck [9].
6. *See* Brucker, M. H. *et al* [1].
7. All systems offered by Michigan State University.
8. *See* Diesslin, H. G. [4].
9. For example, the U.K. Milk Marketing Board's dairy management scheme.

Data input and result output are dependent in part on the type of hardware available. Again a wide variety of systems are used, though in any one case the choice of hardware may be dependent on the type of system. A slow speed terminal is little use in a system requiring large volumes of output in a short time. Currently, there is a tendency to rely on relocatable terminals or on mini-computers where these can adequately handle the job.[10] The advantage of taking the machine to the job is the rapid turnaround and the ability to allow system-farmer interaction. There are even some farmers who hire or purchase their own terminals or mini-computers.[11] It has been suggested[12] that an ideal system is the use of mini-computers to maintain records and provide daily computing capacity as well as having the backup of a large computer to make use of the mini-computer compiled information on an irregular basis. Clearly the optimal arrangement will vary with the kind of system to be operated, and with the experience and educational level of extension officers and farmers.

3 System Uses

Management aids tend to be used in one of three ways though there is some mixture of uses in some cases. The three possibilities are:

(i) as a means of making an initial contact with farmers;
(ii) as an educational tool; and
(iii) as a means of providing farmers with suggestions and data for direct action.

The gimmicks associated with automated systems can provide a drawcard for making contact with farmers that otherwise would not seek advice. The M.A.F.F. in the U.K. use simple systems on mini-computers in this way through exhibiting at agricultural shows. Undoubtedly, however, the major use of automated aids must be classified as educational. Farmers can use the systems to explore alternative plans they have in mind, to provide them with information on which to make decisions and so on. Systems used in this way can be regarded as personalized management games as the farmer has a system relating to his particular farm. Many systems are no doubt designed to provide information that can be directly used in decision making but the complexities of dynamic bio-economic systems are such that it is probably impossible at this stage to be confident of providing directly usable decisions. McCarl *et al* [10] imply a similar conclusion when it is noted that they use models as a focal point in workshop operations. (Extension officers also use aids as self educational devices. For example, the effect of changing prices on optimal systems can be explored. The M.A.F.F. use regional linear programming models in this way.) Of course, simple recording systems are frequently used directly in decision making as usually there is no doubt regarding their potential accuracy.

4 Common Abuses

A major problem in many systems, particularly when first developed, is that they are designed to answer problems that are perceived by the system developer(s) rather than by the farmers. It seems to be a natural hazard for highly trained problem solvers to assume they know all the problems. If farmers do not think a useful answer or information is provided the system will not be used. This will occur whether or not the information is potentially of real benefit and so a necessary component of system development is the seeking of ideas about what farmers (and advisers) think they require.

10. *See* Pugh, C. L. [14]. The M.A.F.F. in the U.K. rely on mini-computers for many of their systems.
11. This is occurring in the U.S.A., Canada and England.
12. Esslemont, R. (*Pers. Comm*), University of Reading.

A similar problem is that many systems cater only for the straight-forward farming organizations so that slight variations cannot be handled. It is certainly difficult to design programmes, input forms and all the other components to cater for all variations but without these allowances some farmers become frustrated with consequent effects on the general acceptance of automated aids. Another area of potential frustration is the use of optimization techniques. Due to the inability to specify objective functions accurately, optimization models can suggest farm plans which are a major change from existing methods used. This leads to non-acceptance so modified optimization systems are commonly more useful. Part of this problem of obtaining acceptance is related to how easy it is for farmers to use the system for the first few times. A complex system that requires extensive quantities of detailed input data commonly deters farmers for life from using aids.

As computers hold some kind of inherent attraction for some people, extension people will sometimes utilize systems relying on computers even though they do not fully understand the principles and practice of the system. The same applies to farmers. These common problems of misunderstanding, which lead to incorrect conclusions and actions, require extensive training programmes to be instituted for both extension agents and farmers.

Another problem area is the adequacy of the computer programmes. The programmes are often developed within universities for research purposes so they are seldom thoroughly tested. Frequently this is due to the tedious nature of testing procedures though there is no reason why computer programmes for testing the systems cannot be developed. These might simulate possible input information and then test output against plausible summary information.

Many of the problems occurring in the past have been due to lack of experience in what is a developing area. Frequently workers in one area have developed management aids without knowing what is being developed in other institutions. Sometimes this occurs as they want their own "special" system. This has meant, for example, that dairy farmers in the U.K. have something like eight automated management aid systems available, many of which overlap. To overcome these problems there is a need for central co-ordination. Possibly there is a place for an organization which specializes in the development of automated aids. This group could satisfy individual requirements by modifying basic models designed for a range of general problem areas.

5 Factors Affecting Success

Besides the points raised above there are many other important factors to consider when designing and implementing an automated management aid. For success the following must be considered.

(i) The selection of the appropriate analytical model to use. This involves allowing for:

(a) farmer capability:[13] the range of abilities means a range of systems is often needed;

(b) the type of problems farmers, and extension people, believe they are faced with;

(c) the accuracy of available technical data and price forecasting methods: if available data is minimal a detailed model is not usually warranted;

13. *See* Buggie, G. J. [2].

(d) the difficulties associated with systems requiring large quantities of data as input: input requirements should be kept to a minimum;

(e) the importance of having farmers actively involved in the procedures through using interactive systems wherever possible.

(ii) Ensuring the physical components of the system are adequate. The requirements are for:

(a) reliable computing facilities;

(b) reliable and timely secretarial services;

(c) appropriately designed data input devices (forms) and output reports. They must be easily understood. Information that is not available must not be requested.

(iii) The availability of appropriate professionals. Essentially there must be available:

(a) a sufficient number of extension personnel who are prepared to utilize the system and undertake the necessary training;

(b) system analysts to develop, and perhaps more importantly, maintain and improve the systems;

(c) an organization to ensure that continuity in systems maintenance and development occurs.

(iv) The nature of the farming community and farms for which the system is designed to assist. The important characteristics to consider are:

(a) the inclination of farmers (or employees) to record and submit data on time;

(b) the attitude of farmers to the acceptance and use of information provided by a system in which they have not been completely involved;

(c) the desire of farmers to change and the extent of change that is possible on the farms;

(d) the ability of farmers to recognize gains made resulting from the use of a system compared with, for example, gains resulting from price rises.

6 Benefits, Costs and Other Factors Affecting Usage

As well as ensuring that all the points raised above are allowed for, it is essential to consider the costs and benefits possible when schemes are being developed and promoted. In many cases it will be important to demonstrate these benefits to potential users in a realistic way. The problem is that quantified objective estimates of benefits do not exist. To date, assessments on whether a system should be developed have been based on subjective opinions and questions of competitive advantage in the commercial arena.

Undoubtedly there are many farmers who consider the aids worthwhile as they continue to use the various systems throughout the world in increasing numbers. The linear programming based crop model operated by Purdue University has been used approximately 5 000 times since 1969.[14] Sixty per cent of the farmers have used the model more than once. The systems

14. McCarl, B., *pers. comm.*, 1977.

offered by Michigan State University have been used heavily in recent years and the trend is still an increasing one. In 1970 some 2 400 "uses" of a range of systems occurred whereas in 1975 the figure was 15 605 (Harsh [7]). In percentage terms, Harrison and Rades [6] found in Illinois and Indiana that 12 per cent of farmers had used an automated management aid in 1972. Some 50 per cent said they could be interested in using aids. As is to be expected, use depends heavily on income and education levels (Eisgruber [5]). While increasing usage does not prove a net benefit, it is some indication. Further, it is frequently found that use of systems increases record keeping and provides an awareness of problems[15] and alternatives. This in itself probably leads to beneficial changes. However, this kind of use of information is unlikely to be all that is necessary to convince farmers that they should use a new scheme, nor does it objectively assist system planners. Thus, studies designed to obtain benefit values must be undertaken in the future. These might involve simple before and after comparisons in relation to control groups over a number of years. Another approach would be to use management games to simulate decision making with and without the use of aids. To assess new schemes in new areas the latter method is the main possibility besides relying on opinion surveys. Both approaches have problems.

On the cost side it is obviously important to ensure charges are realistic in terms of the market situation and the potential benefits. Some schemes will not cover costs so some form of subsidization may need to be considered where net benefits are estimated to exist. Historically, many systems have been developed within universities and so total cost has usually not been a major question. Similarly, the few schemes operated by commercial organizations[16] have relied in part on university assistance.

While commercial groups are reluctant to divulge detailed cost information, reasonable efforts to estimate likely development and running costs are possible from university experience and comments made by commercial operators. It would appear development costs for major schemes have ranged between $60–80,000 depending on the complexity of the system. However, many of the schemes have been pathfinders so there is no reason why these costs cannot be reduced in future. A cost of $40,000 for, say, a linear programming based scheme should be possible. Taking, however, a figure of $70,000 and a fifteen year life the annual charge to repay this cost would need to be approximately $9,200 where the discount rate is 10 per cent. Operating costs for existing schemes appear to be in the vicinity of $5–30 per use. This covers the direct paper, punching, computing and sundry charges. To this cost must be added the extension officer's time if one is directly involved. This charge could be as much as $100 per use of a system. (But, frequently the extension officer would spend this time on the farm anyway—the question is then which way is the time best spent.) The total cost per use depends on how many farmers will use a system. Critical factors are the number of farmers that can potentially use the same, or slightly modified, system and the percentage uptake.[17] Assuming a development cost of $70,000, an operating cost of

15. See, for example, McCarl [11].
16. For example, I.C.I.'s linear programming MASCOT system, BOCM-Silcock's budgeting and control system for pig farmers, and International Harvester's linear programming based crop planning system.
17. As example figures it is worth noting that of 55 000 dairy farmers in the U.K., something like 3½ per cent (figures supplied by the M.M.B., 1977) use a simple milk output forecasting scheme operated by the Milk Marketing Board. Given that similar schemes are operated by other organizations, approximately 4 000 dairy farmers could be involved.

\$15/use, an extension officer cost of \$200/annum, and a use rate of 12 per annum for 1 000 farms, the charge to cover all costs would need to be \$390/annum. Without the extension officer cost this becomes \$190/annum (\$16/month).

While major schemes are expensive to develop and test, simple recording systems involving a small amount of data manipulation can be prepared in a relatively short time and testing is not complex. A development cost of \$20,000 is realistic for many simple schemes.[18] With a monthly operating cost of approximately \$8, a farm population of 5 000, an acceptance rate of 3 per cent (150 farms), the yearly charge would need to be approximately \$130 to break even. If the population was 20 000, this would reduce to around \$105. These figures do not include the extension officer allowance.

There are clearly many variations on these simple examples. The important cost factors, however, are obviously the extension officer contact time and total usage. Cost reducing techniques must be considered in this light and related to their effect on benefits and usage. Minimizing extension officer contact directly related to the operation of the scheme is clearly important where possible. While a completely farmer operated system is sometimes possible, a system in which farmers are brought together into groups for system use and interpretation is a real possibility. Of course, where extension officers are making contact anyway, the marginal cost of contact may be minimal. (All other cost saving procedures must also be considered. Examples are the use of direct data input systems rather than using a several stage process involving card punching.)

Experiences vary on whether extension officers need to be intimately associated with a scheme. This no doubt depends on the type of scheme, the type of farming and the experience and level of education of the farmer. The Milk Marketing Board in England have found farmers can operate a simple milk forecasting and recording system whereas an equally simple egg recording system in New Zealand[19] requires extensive adviser input to be useful. A similar poultry farm recording scheme operated by the N.S.W. Department of Agriculture[20] also relies on considerable extension officer input. Clearly, considerable thought must be given to this question of the place of extension officers and consultants in the operation of management aids. On balance it appears that successful schemes tend to rely on an appreciable time involvement by professionals, at least in their initial years for simple systems and probably constantly for complex aids. Where possible it is desirable for extension officers to be totally conversant with the scheme and this may mean farmers in an area using aids should be dealing with these officers while non-users could be dealing with other extension personnel.

Many automated aids have been disasters. While there are no doubt many reasons for these failures (see sections 4 and 5), a major factor in many cases has probably been the failure to work through a sufficient number of adequately trained extension personnel. Another major factor has been the selection of inappropriate problems. An example of a scheme that experienced difficulties is a simple monthly cash control system operated by Lincoln College in the 1960s.[21] Due to limited funds it was necessary to rely on farmers to input correct data[22] and make effective use of the output. If the whole system,

18. These figures are based on "Programmed Eggs for Profit", Lincoln College.
19. Programmed Eggs for Profit, Lincoln College.
20. Flock Recording Service, Poultry Research Station, Seven Hills.
21. Now operated by the N.Z. Dairy Board as FAMAS in a modified form.
22. With the advent of farmer secretarial services the possibility of training the secretaries to provide the input data has possibilities.

at least in its initial stages, could have been operated through well informed and enthusiastic advisers the system would have been more effective. It appears new systems require effective promotion, demonstration, and back-up before farmers will give them a realistic trial. Most of the successful U.S. schemes rely on a heavy extension agent input, particularly through workshop type arrangements.

Looking to the future, an important question in increasing the potential usage of aids is whether they can be developed to provide an automated decision making system requiring a minimum of human inference. Currently most aids are only capable of assisting in problem understanding so the decision maker's intuition and reasoning is called upon to make the final decision. This occurs in part due to the extreme complexity of bio-economic systems and the lack of technical data. To move beyond this stage, and to improve currently available aids, it will be necessary to devote research funds to the development of:

(a) methods of quantifying objectives that are operationally useful;

(b) ways of objectively simplifying models which represent the complex bio-economic system so that they become solvable but remain realistic representations of the real world;

(c) price forecasting methods as sophisticated models are no better than simple decision rules where forecasting is unreliable;

(d) farmer attitudes to using aids and the relationship between the designs used and acceptance; and

(e) the provision of reliable technical information.

Unless objectives can be quantified optimizing routines are going to be misleading and, similarly, unless the correct input-output information is used a "back of envelope" calculation may well provide information as useful.

Currently, models of farm systems tend to be simplified on subjective grounds rather than on objective assessment, simply because totally realistic models have never been built. Of course, even if such models existed they would not provide useful information if price forecasting is not reliable. Many price forecasting models have explained past trends but are often less successful in predicting turning points.

7 Conclusion

Automated management aids are beginning to bring to the farmer the ideas of the last twenty years of theoretical research. Farmer acceptance in some countries indicates these developments at least appear to provide useful information. For this reason, and because an increasing number of workers are becoming involved in the area, more systems will be developed and used. The increasing number of professionals in the area will ensure this, whether or not the schemes developed are justified.

The availability of increasingly sophisticated electronic computers, both large and small, as well as the software developments, is providing a means by which the real world can be used as the laboratory for testing the usefulness of management aids. In the past hypothetical cases have often been used to develop decision models.

For a continuing useful growth of management aids care must be exercised in selecting the problems to be handled and the techniques to be used. Currently, the problems which are most suitable for selection are those:

(a) in which detailed technical information is available, or is not necessary;

(b) which apply to a large number of farmers in basically the same form;

(c) that are essentially simple and require minimal input information and solution reporting;

(d) are economically important and this is recognized by the farmers; and

(e) where extension officers/consultants are keen to use and promote the system and they can devote time to farmer contact specifically related to the scheme, at least initially in its development.

If these conditions are not satisfied, the scheme is likely to be a failure. Finally, it should be noted that even for problems and systems that are carefully selected experience has shown that it is unlikely that more than 10 per cent of eligible farmers will use a scheme [5, 6].

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