



**AgEcon** SEARCH  
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

*The World's Largest Open Access Agricultural & Applied Economics Digital Library*

**This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.**

**Help ensure our sustainability.**

Give to AgEcon Search

AgEcon Search  
<http://ageconsearch.umn.edu>  
[aesearch@umn.edu](mailto:aesearch@umn.edu)

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

STEVEN T. SONKA

*Computer-Aided Farm Management Systems:  
Will the Promise be Fulfilled?*

The topic of computer-aided farm management is very broad and a discussion of it should encompass the contributions of experts in several scientific disciplines. Even in the framework of the agricultural economics profession, there are numerous factors that one could consider when addressing this topic. Given the constraints of length imposed, however, this paper will not survey the broad range of topics possible. Instead the limited scope of the direct use of microcomputers on commercial farms will be the paper's focus. Doing this does not imply that other issues, such as the use of mainframe computers for provision of information or the use of microcomputers by advisors of limited resource farmers, are not also important.

POTENTIAL ON-FARM USES OF THE MICROCOMPUTER

The introduction and phenomenal growth of the capability of microcomputers has vastly expanded the potential number of individuals and small businesses who can afford to become computer owners. Commercial farm operators now can purchase microcomputers with significant computing capacity for less money than many of the farm machinery and equipment items they routinely buy.

In the few years since microcomputers have become available, this technology has been applied in numerous farm management applications. In the planning and control functions, the potential for microcomputer use has been exploited on a few farms. Simulation programmes have been used to help producers clarify the trade-offs between conflicting goals. The information acquisition capability of the computer has helped some producers forecast prices and production. Programmes to aid operational planning, investment analysis and whole farm planning have assisted in formulating long- and short-term plans. Accounting and physical production record programmes are available to enhance the control function. Similarly software exists which allows the producer to automate many administrative duties, such as payroll, tax reporting and activity monitoring.

Although computers have been used for the previously mentioned applications, the vast majority of commercial farmers do not own microcomputers for business use. Probably no more than one in ten commercial US farmers uses a microcomputer for business purposes. And there is indication that the rate of computer adoption may not be increasing among farmers. Therefore in the following sections, a number of management-related impediments to effective microcomputer implementations on farms will be discussed.

### FACTORS AFFECTING FURTHER ADOPTION

The appropriate role of computers in society and the ultimate effect of markedly increased levels of computer use are issues of growing concern (Turkle 1984). These are legitimate issues and are worthy of analysis and debate. Those discussions, however, are outside the scope of this paper. Therefore, as a working hypothesis, let us assume that microcomputers have potential value in improving the farm management process. Using this hypothesis, the remainder of this discussion will consider a limited number of factors which appear to be significant impediments to the future adoption and effective utilisation of microcomputers on farms.

The following discussion will intentionally not include predictions of technological change with respect to computer hardware. Continual improvement is assumed.

### ASSESSING THE VALUE OF A NEW TECHNOLOGY

One of the appropriate activities for agricultural economists is to assess the value of a new technology. Our profession has contributed many useful analyses to this end. At times we have estimated the pay-off to the individual producer for being an early adopter of an innovation. In other situations the perspective considered was that of a region, nation or the world. Despite this long and valued tradition, there is very little in our literature which addresses the economic value of computers and specifically the value of the on-farm microcomputer.

Farm decision-makers, however, are vitally interested in knowing the economic pay-off from investing in a computer. On numerous occasions I have spoken to farm groups about computer use and am invariably faced with questions such as, 'Will this machine make me any money? Will investing in a computer have a higher rate of return than applying more fertilizer?' My replies to such questions have been uniformly unsatisfactory. There are only so many ways to essentially say, 'It depends'. It is of little comfort to suspect that my colleagues also have little to offer in reply to these questions.

This issue is raised not to point out a shortcoming of our profession. Instead prior research suggests that the perceived relative advantage of an innovation affects the rate of adoption of that innovation (Rogers 1971). Therefore the lack of a rigorously determined answer to these

questions is likely to be an impediment to the successful application of computers in agriculture. Because of this, it seems warranted to discuss alternative approaches to assessing the value of the computer innovation. In addition, a framework for addressing the issue of economic valuation will be proposed.

### ANECDOTAL EVIDENCE

The most common approach to defining the value of microcomputers to the farmer seems to have been to rely on anecdotal evidence. Testimony from actual farmers has the important attribute of establishing credibility for the technology, which was an important factor when microcomputers were new and unusual. This expert testimony relied totally on that individual's experience. Acquisition costs and the process of learning how to utilise a limited number of programmes often were defined. The 'value' of the technology was expressed in subjective terms. In some cases, the role of the computer in changing a major decision was described. For these latter cases, the gain from that one decision always seemed to 'more than pay for the computer'.

### FOCUSING ON COSTS

A second and more quantitative approach has been to focus only on the cost side of computer use (Sonka 1983). In a few cases, it is possible that the introduction of the microcomputer would not affect the amount or quality of information available for farm decision-making. For example, computerising the farm payroll or implementing a computerised farm accounting system which duplicated the previous system would result in no information gains for decision-making. In those instances a partial budget framework would be appropriate. We could compare:

<i>Additional costs of the computerized system</i>	versus	<i>Reduced costs of the manual system</i>
Search costs		Transactions processing
Learning costs		Calculation costs
Hardware acquisition cost		
Software acquisition cost		

In most instances, however, the farm information system expands with the addition of microcomputer capabilities. Focusing on the cost side provides no indication of the value of the enhancements to the information system. Quantifying the total costs, however, may provide a useful reference point for the potential computer adopter.

### AN APPROACH TO VALUING THE BENEFITS OF COMPUTER USE

Valuing the benefits of computer adoption is directly related to the

computer's impact on the farm information system. The benefits of computer use will be derived from the information obtained by utilising that technology. Although quantitative estimation of the value of information is not a trivial process, frameworks do exist which can help us conceptualize the problem (Chavas and Pope 1984). Further, application of innovative research approaches could lead to quantitative estimates if the problem area is recognized as one worthy of investigation.

The farm decision-making problem has several important attributes. Among these are that it is dynamic and that interrelated decisions are made sequentially. The presence of time in the process implies that the outcome of today's decision will be affected by stochastic future events. A helpful framework in which to consider this setting is that of a stochastic, dynamic programming problem. Applying the principle of optimality results in the following recursive objective function:

$$V_t(X_t) = \max [r_t(X_t, D_t) + (BEV_{t+1})(X_{t+1})] \quad (1.1)$$

where  $X_t$  = a state variable describing the state of the farm decision process at stage  $t$ ,

$D_t$  = the decision chosen by the decision-maker at stage  $t$ ,

$V_t(D_t)$  = expected optimal outcome from following an optimal policy from the current stage  $t$  to the final stage ( $T$ ) for a decision-maker currently at state  $X_t$ ,

$r_t$  = a valuation process for stage  $t$  which is a function of state  $X_t$  given the decision  $D_t$  (if the farmer is a profit maximiser,  $r_t$  is a function which computes profits; if the producer is a utility maximiser,  $r_t$  is a utility function)

$B$  = discount factor,

$E$  = expectation operator,

$\max$  = maximisation operator.

The recursive equation in (1.1) is maximised subject to the following transition equation:

$$X_{t+1} = t_t(X_t, D_t, Z_t, O_t) \quad (1.2)$$

where  $t_t$  = a transformation function from stage  $t$  to  $t + 1$ .

$Z_t$  = exogenous variables at stage  $t$ , and

$O_t$  = the stochastic events occurring at stage  $t$ .

The presence of  $O_t$  implies that the transition equation is stochastic (i.e. we can think of the transition relationship in terms of probabilities).

What do the two equations (1.1) and (1.2) attempt to represent? In words, we have a farm decision-maker striving to maximise some goal structure. The producer's current situation is the product of past decisions, exogenous forces and stochastic events. Similarly the future circumstances of that producer will be a result of decisions made today, stochastic events that will occur and exogenous influences. This

framework can be defined very generally. Let the possible decisions include financial, marketing and production decisions. Further the stages could be short, i.e. daily, or relatively long, i.e. annually.

If we could quantify the relationships of (1.1) and (1.2), then an estimate of the value of information resulting from adoption of a microcomputer could be obtained. That value would be the difference between  $V_t^c(X_t)$  and  $V_t^o(X_t)$  where  $V_t^c(X_t)$  is the value of the expected optimal outcome using a microcomputer and  $V_t^o(X_t)$  is the analogous value without the microcomputer. Later we will speculate on some approaches to quantitative estimation. Now let us focus on how the presence of a computerised information system might affect the parameters of (1.1) and (1.2).

One of the uses of a microcomputer is to access external information. Indeed the 'electronic cottage' concept supposes that individuals will readily adopt and utilise electronic communication networks. Accessing external information would affect the terms  $EV_{t+1}(X_{t+1})$ ,  $O_t$ , and  $Z_t$ . Producers with improved access to futures market quotations, or weather forecasts may have subjective probability distributions which are more accurate than do producers without that capability. Here there must be some attribute of using the electronic communication system which differentially affects expectations. If the microcomputer user receives the same information but through a more 'modern' medium, the evaluation issue is one of comparing costs of acquisition. It is possible, however, that the near real time access of electronic communications and the enhanced capability to analyse electronically received data may result in differing expectations and decisions.

The term  $t_t$  is analogous to a production function. An enhanced information system could affect this term in two ways. One is by changing the coefficients because of increased efficiency. Remember that all the activities of the farm are considered here so that more efficient operation would include improvements to monitoring and administrative activities. A second avenue by which the transition function could be altered is if the producer developed a more accurate perception of those coefficients. For example computerised production records might indicate that the firm's technical performance was not as efficient as the producer relying solely on memory might have believed.

Occasionally the agricultural economics literature has contained discussions which debate the value of accounting and/or recordkeeping systems (Hardaker and Anderson 1981). If computerised versions of those monitoring activities are to have value for decision-making, that value will result because those activities provide better estimates of the current state of the process, the  $X_t$  variable. Remember again that we have defined the decision set very broadly, so that financial and marketing activities are included. If use of a computer for monitoring purposes does not alter the producer's knowledge of  $X_t$ , then it is likely that this use will have minimal value for managerial purposes.

The final term which seemingly could be affected by the information system available is the  $r_t$  term. Let us consider a producer who uses the computer solely for forward planning purposes. When evaluating a decision, the computer is used to compute expected outcomes, i.e. net cash flows or profit. In addition to the most likely outcome, possibly a range of outcomes or a sensitivity analysis, is computed. It is possible that the producer with the microcomputer could reach a different decision even though the coefficients used (the expected prices and technical relationships) were identical whether a computer was used or not. In this situation, the contribution of the computer is to increase the producer's understanding of the relationship between the goals being maximised and the decision situation currently being considered.

Given that general formulation of the decision situation, how might we approach empirical analyses? The likely first step would be to narrow the scope for the analysis to a specific computer application and a limited set of decisions. Observation of the effects of computer use in actual decision situations probably will be unsatisfactory. Too many other factors will be influencing the decisions selected, in addition to the use of computers, to isolate the computer effect. Note that case studies or surveys describing actual computer use can be quite valuable to producers and to researchers. The point here is that such investigations are not likely to generate estimates of the economic value of the innovation.

Two other approaches may provide insights into the valuation issue. These are the uses of simulation and experimental analysis. Both techniques have shortcomings because they abstract from the real world decision setting. Yet the careful use of these techniques may contribute to our understanding of the economics of the microcomputer technology and information use.

In the simulation approach, the basic concept would be to predict decision behaviour with and without information items derived from computer use. In essence the researcher would systematically alter parameters in the decision model to reflect with and without information scenarios. The goal of the analysis would be to determine if the producer's predicted behaviour would be altered by the presence of information. Major problems with the approach revolve around specifying the decision rules (the relationship between the value of a variable and the decision selected) and quantifying how specific parameters are altered because of the presence of information.

Actual decision-makers could possibly be part of the analysis but in an experimental setting. For a very structured situation, producers would be given differing levels of information and the decisions they select recorded. Given sufficient resources, the interaction of information, the producer's current financial position, and future expectations could be examined. This method suffers because the decision-maker is not operating in an actual decision environment. If producers are presented with unfamiliar information, their experimental response may differ from what their actual behaviour would be once they were familiar with using

the information. Further the producer in actuality may be affected by factors which cannot be replicated in the experimental setting.

As one contemplates construction of a simulation model to evaluate the effect of computer-generated information, our lack of understanding of actual decision making behaviour becomes more apparent. In one sense, conducting an experimental analysis or examination of actual behaviour are means to generate the needed coefficients for the decision model. The previous discussion has been directed towards the economic valuation of computer use. An additional implication of that discussion is that we need to know much more about actual decision processes if we are to provide increasingly realistic evaluations for many of the problems faced by producers.

### CAPTURING INTERNAL DATA

In terms of production, a farm firm is very similar to a manufacturing firm. Inputs are combined and after time has elapsed, a new product is produced. Just as in a manufacturing firm, a substantial number of activities are often required before production is completed. The historic capability of the farm firm to monitor those activities, however, has been quite limited. There are several reasons for this. When farms are small and the number of production practice alternatives are limited, the benefits from formally monitoring activities are minimal. In addition the physical environment of farming is not conducive to accurate measurement and recording. And finally a farmer prefers farming to being a clerk.

Microcomputer systems which are purchased to provide better estimates of the farm's current state variable (the  $X_t$  of the previous section) are often constrained by the availability of high quality data on internal transactions. In some cases, microcomputer systems have been judged unsatisfactory even though the hardware and software were adequate. The 'failure' in the system was the producer's internal data capturing system, which did not produce the observations required for the microcomputer to be effective. In economic terms, the farmer perceived that the cost of obtaining the data exceeded the potential benefits.

Innovative application of microelectronics promises to reduce these data capture costs. Already the transponder for dairy animals has received considerable testing. Additional electronic advances are likely to make the data capturing process more accurate and less of a burden for the farmer or the farm worker. Such innovations could greatly alter the farmer's perceived cost/benefit ratio for enhanced information systems. Also it appears that management researchers could contribute significantly to the development of these innovations.

### DIVERSE NEEDS OF INDIVIDUAL PRODUCERS

Although we are not certain to what extent management is an art or a science, the management process followed on any two farms is not likely to



be identical. In a recent project a small number of farmers cooperated with university researchers to rigorously identify their financial accounting needs (Schnitkey 1984). Although these producers were fairly homogeneous in terms of size and enterprises, the number of separate accounts they specified as needed varied from 63 to 222. Clearly a single microcomputer system would not be equally satisfactory to each of these producers.

Research relating to the information of individual producers is likely to document differing management styles on farm firms. Many alternative categorisations of those management approaches will be possible. One which has been hypothesized recently is that of the information age farm versus the industrial age farm (Sonka 1985). The basic distinction suggested is the extent to which information is used in the management process. On the industrial age farm, strategies which are perceived best under average conditions are routinely employed. Conversely the management approach of the information age farm strives to implement flexible management strategies.

A flexible management strategy allows for continual re-evaluation of plans as the producer's decision environment changes or is expected to change. The role of information is to document and/or predict those changing conditions. Microcomputers can play a part in this process if their use leads to more efficient provision of the needed information.

A major impediment to the development of flexible management strategies is the lack of appropriate production coefficients. Systems simulation models of physical and biological processes can be a means of quantifying coefficients in a manner which is meaningful to managers. Bioeconomic modelling efforts which combine or integrate physical and economic systems will allow researchers to test flexible strategies in varied settings. Such research efforts would seem to have value for the producer striving to be more efficient. As the capacity of microcomputers continues to expand, it also is realistic to envisage producers independently utilising such models. Rather than expecting these models to produce 'optimal' solutions which the producer religiously adopts, a more realistic use of such models would be to allow the producer to develop a better understanding of the physical and economic systems with which the producer is working.

## EXPERT CONSULTATION

The farm decision environment is becoming increasingly complex. Often the input of relatively specialised expertise is desirable. However, the geographic dispersion of agricultural production and the relatively small scale of the farm firm has traditionally made it uneconomic to acquire the services of the expert. A limited set of evidence suggests that innovative farm producers have attempted to overcome these barriers and to utilise the outside consultant. Effective use of that expertise is often a function of the availability of internal firm data. The value of computerised

systems may be enhanced if there are significant advantages to the use of external consultants.

Advances in the area of artificial intelligence suggest that computerised delivery of expert consultation is currently possible and will be increasingly so in the future. As these capabilities become more powerful, the value of using the farm computer as a learning tool may exceed that associated with current applications of the technology. Development of expert systems will require considerable resources. This will be a particularly challenging task for farm management researchers. A major component of that task will be to define what the 'rules' are in farm financial and business management.

### COMPUTER LITERACY

Computer literacy is the subject of intense debate today. As typically phrased, the issue revolves around the instruction needed to allow current and future decision-makers to effectively utilise the computer technology. But that typical debate seems to have the emphasis exactly backwards. Rather than focusing on how people have to change to use computers, should not the proper question be, 'How do computer systems have to change to be most appropriate for use by people?'

With respect to management of the farm, farm management researchers and educators have much to contribute to the development of more effective software. In the past few years, individuals in these areas have often provided leadership in software development and review. But it appears, probably by necessity, that we have been quite willing to utilise informal criteria for programme evaluation.

Now that we are beginning to have an actual experience base to examine, part of our focus should shift to more rigorous analysis of the effect of computer systems on decision-making. These investigations could examine the characteristics of computer systems that seem to contribute to more effective decision-making. For example, a recent study of a limited sample of pork producers suggests that producers who design and implement their own record system using general purpose software tend to make more extensive use of the resulting information (Schroeder 1984). If this finding is valid in general, it has important implications for the need for software which can accommodate very flexible designs, implementable by individual users. There are numerous other system design issues of importance. Careful research which focuses on the management needs of producers is needed. In essence, computer system design may be too important to be left to computer professionals.

### SUMMARY

Our limited experience with microcomputer use in farm management gives several reasons for the optimistic belief that this technology can be an aid to effective farm decision making. Enough experience has been

accumulated, however, to indicate that implementation of this technology can sometimes be a painful and frustrating experience. Many of the impediments to successful use relate to interfacing existing management practices and needs to the capabilities of the technology. In many of these instances, the input of farm management researchers and educators could be of valuable assistance.

## REFERENCES

- Chavas, J.-P. and Pope, R. D., 'Information: its Measurement and Valuation, *American Journal of Agricultural Economics*, vol. 6, 1984. pp. 705-710.
- Hardaker, J. R. and Anderson, J. R., 'Why Farm Recording Systems are Doomed to Failure?', *Review of Marketing and Agricultural Economics*, vol. 49, 1981, pp. 199-202.
- Rogers, E. M., *Communication of Innovations*, The Free Press, New York, 1971.
- Schnitkey, G. D., 'Accounting Systems for Farms: Design and Selection Methods', unpublished M.S. thesis, University of Illinois at Urbana-Champaign, 1984.
- Schroeder, R. C., 'Computerized Production Records for Swine Producers: An Evaluation of Current and Potential Uses', unpublished M.S. thesis, University of Illinois at Urbana-Champaign, 1984.
- Sonka, S. T., 'Information Management in Farm Production', *Journal of Computers and Electronics in Agriculture*, 1985.
- Sonka, S. T., *Computers in Farming: Selection and Use*, McGraw-Hill, New York, 1983.
- Turkle, S., *The Second Self: Computers and the Human Spirit*, Simon and Schuster, New York, 1984.