MANAGEMENT INFORMATION SYSTEMS

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INTRODUCTION

Management information systems encompass a broad and complex topic. To make this topic more manageable, boundaries will be defined. First, because of the vast number of activities relating to management information systems, a total review is not possible. Those discussed here is only a partial sampling of activities, reflecting the author's viewpoint of the more common and interesting developments. Likewise where there were multiple effects in a similar area of development, only selected ones will be used to illustrate concepts. This is not to imply one effort is more important than another. Also, the main focus of this paper will be on information systems for use at the farm level and to some lesser extent systems used to support researchers addressing farm level problems (e.g., simulation or optimization models, geographic information systems, etc.) and those used to support agribusiness firms that supply goods and services to agricultural producers and the supply chain beyond the production phase.

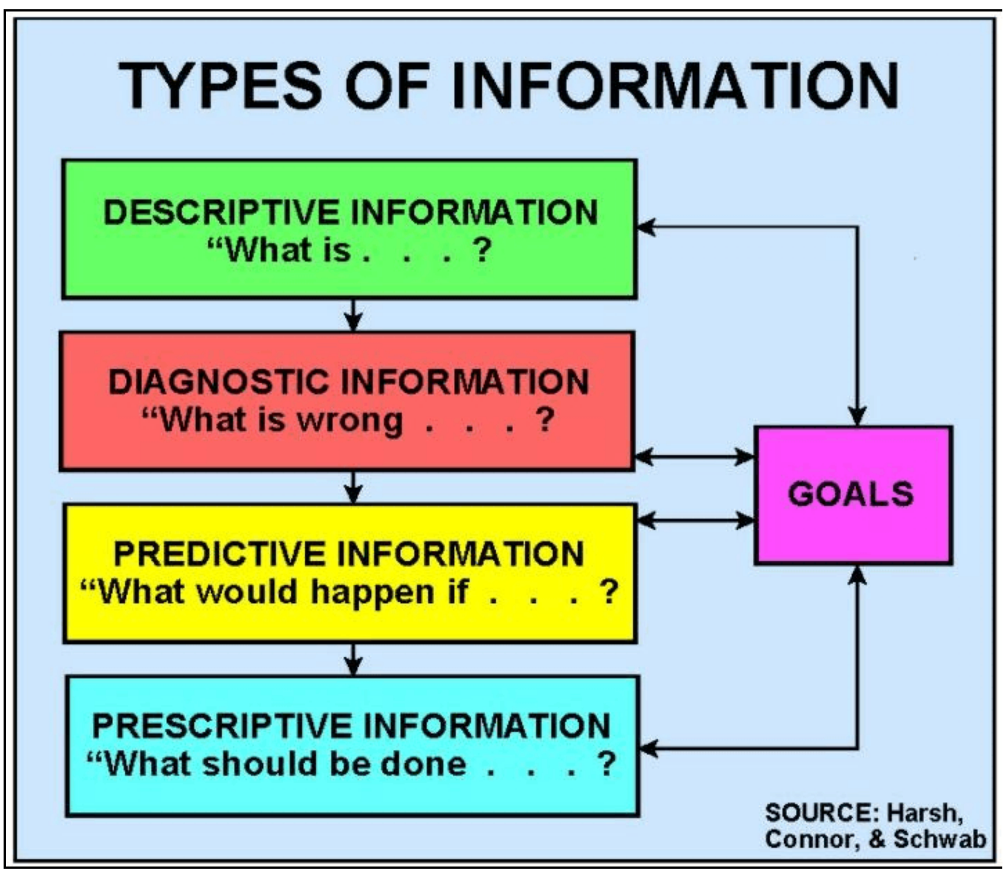
Secondly, there are several frameworks that can be used to define and describe management information systems. More than one will be used to discuss important concepts. Because more than one is used, it indicates the difficult of capturing the key concepts of what is a management information system. Indeed, what is viewed as an effective and useful management information system is one environment may not be of use or value in another.

Lastly, the historical perspective of management information systems cannot be ignored. This perspective gives a sense of how these systems have evolved, been refined and adapted as new technologies have emerged, and how changing economic conditions and other factors have influenced the use of information systems.

Before discussing management information systems, some time-tested concepts should be reviewed. Davis offers a commonly used concept in his distinction between data and information. Davis defines data as raw facts, figures, objects, etc. Information is used to make decisions. To transform data into information, processing is needed and it must be done while considering the context of a decision. We are often awash in data but lacking good information. However, the success achieved in supplying information to decision makers is highly variable. Barabba, expands this concept by also adding inference, knowledge and wisdom in his modification of Haechel's hierarchy which places wisdom at the highest level and data at the lowest. As one moves up the hierarchy, the value is increased and volume decreased. Thus, as one acquires knowledge and wisdom the decision making process is refined. Management information systems attempt to address all levels of Haechel's hierarchy as well as converting data into information for the decision maker. As both Barabba and Haechel argue, however, just supplying more data and information may actually be making the decision making process more difficult. Emphasis should be placed on increasing the value of information by moving up Haechel's hierarchy.

Another important concept from Davis and Olsen is the value if information. They note that “in general, the value of information is the value of the change in decision behavior caused by the information, less the cost of the information.” This statement implies that information is normally not a free good. Furthermore, if it does not change decisions to the better, it may have no value. Many assume that investing in a “better” management information system is a sound economic decision. Since it is possible that the better system may not change decisions or the cost of implementing the better system is high to the actual realized benefits, it could be a bad investment. Also, since before the investment is made, it is hard to predict the benefits and costs of the better system, the investment should be viewed as one with risk associated with it.

Another approach for describing information systems is that proposed by Harsh and colleagues. They define information as one of four types and all these types are important component of a management information system. Furthermore, the various types build upon and interact with each other. A common starting level is *Descriptive* information. (See Figure 1). This



1 Figure 1 – Types of Information

information portrays the “what is” condition of a business, and it describes the state of the business at a specified point in time. Descriptive information is very important to the business manager, because without it, many problems would not be identified. Descriptive information includes a variety of types of information including financial results, production records, test results, product marketing, and maintenance records.

Descriptive information can also be used as inputs to secure other needed types of information. For example, “what is” information is needed for supplying restraints in analyzing farm adjustment alternatives. It can also be used to identify problems other than the “what is” condition. Descriptive information is necessary but not completely sufficient in identifying and addressing farm management problems.

The second type of information is *diagnostic* information, This information portrays this “what is wrong” condition, where “what is wrong” is measured as the disparity between “what is” and “what ought to be.” This assessment of how things are versus how they should be (a fact-value conflict) is probably our most common management problem. Diagnostic information has two major uses. It can first be used to define problems that develop in the business. Are production levels too low? Is the rate earned on investment too low? These types of question cannot be answered with descriptive information alone (such as with financial and production records). A manager may often be well supplied with facts about his business, yet be unable to recognize this type of problem. The manager must provide norms or standards which, when compared with the facts for a particular business, will reveal an area of concern. Once a problem has been identified, a manager may choose an appropriate course of action for dealing with the problem (including doing nothing). Corrective measures may be taken so as to better achieve the manager’s goals. Several pitfalls are involved for managers in obtaining diagnostic information. Adequate, reliable, descriptive information must be available along with appropriate norms or standards for particular business situations. Information is inadequate for problem solving if it does not fully describe both “what is” and “what ought to be.”

As description is concerned with “what is” and diagnostics with ”what is wrong,” *prediction* is concerned with “what if...?” Predictive information is generated from an analysis of possible future events and is exceedingly valuable with “desirable” outcomes. With predictive information, one either defines problems or avoids problems in advance. Prediction also assists in analysis. When a problem is recognized, a manager will analyze the situation and specify at least one alternative (including doing nothing) to deal with it. Predictive information is needed by managers to reduce the risk and uncertainty concerning technology, prices, climate, institutions, and human relationships affecting the business. Such information is vital in formulating production plans and examining related financial impacts. Predictive information takes many forms. What are the expected prices next year? What yields are anticipated? How much capital will be required to upgrade production technologies? What would be the difference in expected returns in switching from a livestock farm to a cropping farm? Management has long used various budgeting techniques, simulation models, and other tools to evaluate expected changes in the business.

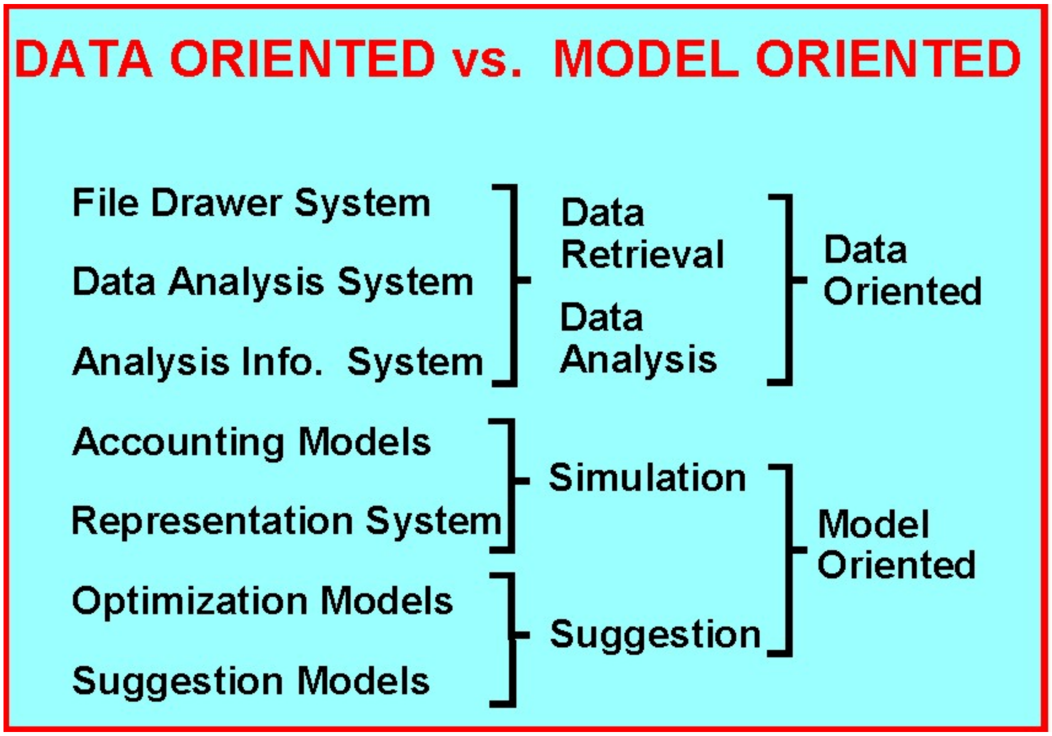
Without detracting from the importance of problem identification and analysis in management, the crux of management tasks is decision making. For every problem a manager faces, there is a "right" course of action. However, the rightness of a decision can seldom, if ever, be measured in absolute terms. The choice is conditionally right, depending upon a farm manager's knowledge, assumptions, and conditions he wishes to impose on the decision. *Prescriptive* information is directed toward answering the "what should be done" question. Provision of this information requires the utilization of the predictive information. Predictive information by itself is not adequate for decision making. An evaluation of the predicted outcomes together with the goals and values of the manger provides that basis for making a decision. For example, suppose that a manager is considering a new changing marketing alternative. The new alternative being considered has higher "predicted" returns but also has higher risks and requires more management monitoring. The decision as to whether to change plans depends upon the managers evaluation of the worth of additional income versus the commitment of additional time and higher risk. Thus, the goals and values of a farm manager will ultimately enter into any decision.

HISTORICAL PERSPECTIVE

The importance of management information systems to improve decision making has long been understood by farm management economists. Financial and production records have long been used by these economists as an instrument to measure and evaluate the success of a farm business. However, when computer technology became more widely available in the late 1950s and early 1960s, there was an increased enthusiasm for information systems to enhance management decision processes. At an IBM hosted conference, Ackerman, a respected farm management economist, stated that:

> "The advances that have taken place in calculating equipment and methods make it possible to determine the relationship between ultimate yields, time of harvest and climatic conditions during the growing season. Relationship between the perspective and actual yields and changing prices can be established. With such information at hand the farmer should be in a position to make a decision on his prediction with a high degree of certainty at mid-season regarding his yield and income at harvest time."

This statement, made in 1963, reflects the optimism that prevailed with respect to information systems. Even though there was much enthusiasm related to these early systems they basically concentrated on accounting activities and production records. Examples include the TelFarm electronic accounting system at Michigan State University and DHIA for dairy operations. These early systems relieved on large mainframe computers with the data being sent to a central processing center and the reports send back to the cooperating businesses. To put these early efforts into a management information system framework, the one proposed by Alder (House,ed.) is useful. (See Figure 2). They would be defined as data oriented systems with



2 Figure 2 – Types of Information Systems

limited data analysis capabilities beyond calculating typical ratios (e.g., return on assets, milk per cow, etc.).

By the mid 1960s it became clear that the accounting systems were fairly effective in supplying descriptive and diagnostic information but they lacked the capacity to provide predictive and prescriptive information. Thus, a new approach was needed – a method of doing forward planning or a management information system that was more model oriented. Simulation models for improving management skills and testing system interaction were developed. As an example, Kuhlmann, Giessen University, developed a very robust and comprehensive whole farm simulation model (SIMPLAN) that executed on a mainframe computer. This model was based on systems modeling methods that could be used to analyze different production strategies of the farm business. To be used by managers, however, they often demanded that the model developer work closely with them in using the model.

Another important activity during this period was the "Top-Farmer Workshops" developed by Purdue University. They used a workshop setting to run large linear-programming models on mainframe computers (optimization models) to help crop producers find more efficient and effective ways to operate their business.

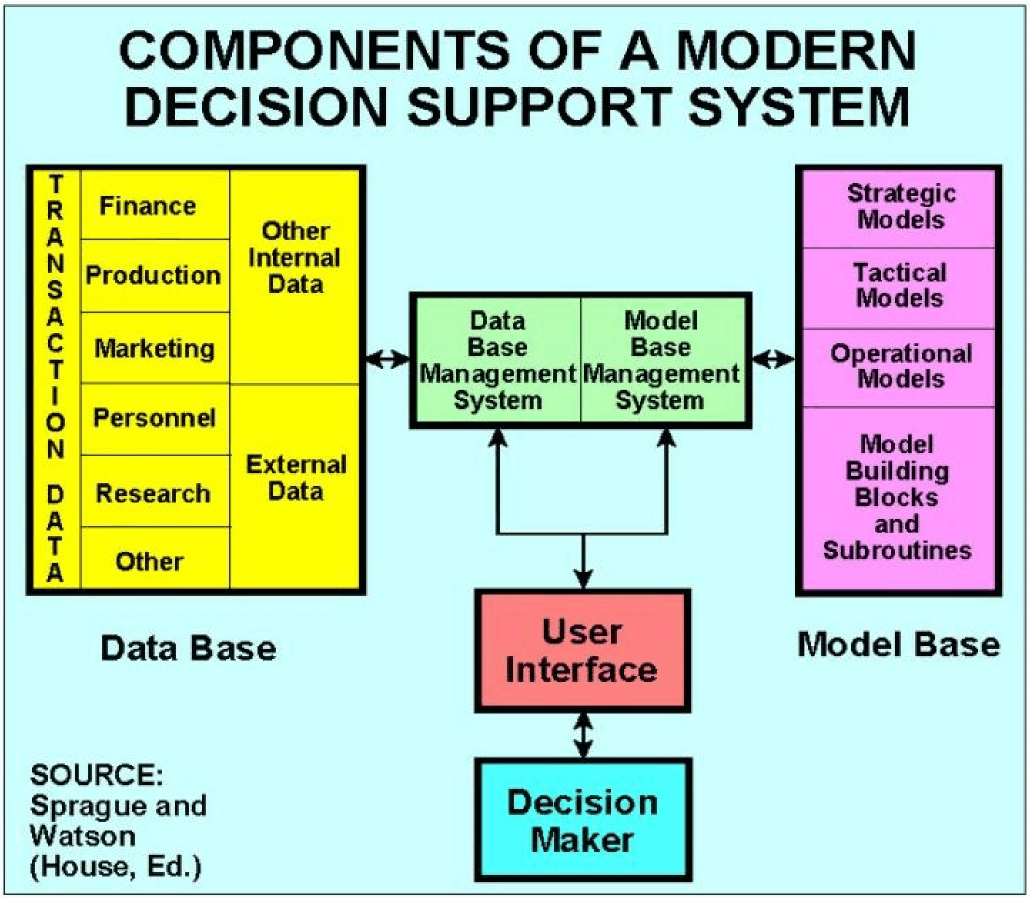
As mainframe timeshare computers emerged in the mid-1960's, I became possible to remotely access the computer with a terminal and execute software. Systems such TelPlan developed by Michigan State University made it possible for agricultural producers to run a farm related computer decision aids. Since this machine was shared by many users, the cost for executing an agriculturally related decision aid was relatively inexpensive and cost effective. These decision aids included optimization models (e.g., least cost animal rations) budgeting and simulation models, and other types of decision aids. These decision aids could be accessed by agricultural advisor with remote computer terminals (e.g., Teletype machine or a touch-tone telephone). These advisors used these computer models at the farm or at their own office to provide advice to farm producers.

These were exciting times with many people becoming involved in the development, testing, refining, and implementation of information systems for agriculture. Computer technology continued to advance at a rapid pace, new communication systems were evolving and the application of this technology to agriculture was very encouraging. Because of the rapid changes occurring, there were international conferences held where much of the knowledge learned in developing these systems was shared. One of the first of these was held in Germany in the mid-1980s.

It was also clear from these early efforts that the data oriented systems where not closely linked to the model oriented systems. Information for the data oriented systems often did not match the data needed for the model oriented systems. For example, a cash-flow projection model was not able to directly use financial data contained in the accounting system. In most cases, the data had to be manually extracted from the accounting system and re-entered into the planning model. This was both a time consuming and error prone process.

Because of the lack of integration capabilities of various systems, they were devoid of many of the desirable characteristics of an evolving concept describes as decision support systems (DSS). These systems are also known as Executive Support Systems, and Management Support System, and Process Oriented Information Systems . The decision support system proposed by Sprague and Watson (House, ed.) Has as its major components a database, a modelbase, a database/modelbase management system and a user interface (see Figure 3). The *database* has information related to financial transactions, production information, marketing records, the resource base, research data, weather data and so forth. It includes data internally generated by the business (e.g., financial transactions and production data) and external data (e.g., market prices). These data are stored in a common structure such that it is easily accessible by other database packages as well as the modelbase.

The *modelbase* component of the system has decision models that relate to operational, tactical and strategic decisions. In addition, the modelbase is able to link models together in order to solve larger and more complex problems, particularly semi-structured problems. The *database/modelbase management system* is the bridge between database and modelbase components. It has the ability to extract data from the database and pass it to the modelbase and vice versa. The *user interface*, one of the more critical features of the system, is used to assist the decision maker in making more efficient and effective use of the system. Lastly, for these systems to be effective in supporting management decision, the *decision maker* must have the



3 Figure 3 – Decision Support System

skills and knowledge on how to correctly use these systems to address the unique problem situation at hand.

Several follow-up international conferences were held to reflect these new advances in management information systems. The first of these conferences focused on decision support systems was held in Germany. This conference discussed the virtues of these systems and the approach used to support decisions. Several prototype systems being developed for agriculture were presented. From these presentations, it was clear that the decision support systems approach had many advantages but the implementation in agriculture was going to be somewhat involved and complex because of the diversity of agricultural production systems. Nevertheless, there was much optimism for the development of such systems.

A couple of years later, another conference was held in Germany that focused on knowledge-based systems with a major emphasis on expert systems and to a lesser extent optimum control methods and simulation models. Using Alter's scheme to describe information systems, for the most part these would be described as suggestion models. It was interesting to note that the prototype knowledge-based systems for the most part did not utilize the concepts of decisions support systems which was the focus of the earlier conference. Perhaps this was related to the fact that many of the applications were prototypes.

The international conference that followed in France focused on the low adaption rate of management information systems. This was a topic of much discussion but there were few conclusions reached except the systems with the highest adaption rate were mainly data-oriented ones (e.g., accounting systems, field record systems, anaimal production and health records, etc.) which provide mainly descriptive and diagnostic information.

The international conferences that followed had varying themes. One of the major themes was precision agriculture with several conferences held. These conferences extolled the use of geographic information systems (GIS) in conjunction with geographic positioning systems (GPS) to record and display data regarding cropping operations (e.g., yields obtained) and to control production inputs (e.g., fertilizer levels). Other conference addressed the use of information systems to more tightly control agriculture production such as those developed for greenhouse businesses.

To briefly summarize the historical developments, there have been significant efforts devoted to improving the management information systems from the early computerized activities forty years earlier. The decision aids available have grown in number and they are more sophisticated. There has been some movement toward integration of the data oriented systems and the model oriented systems. An examination of our current usage of management information systems, however, suggests that we have not nearly harnessed the potential of the design concepts contained modern management information systems.

CURRENT STATUS OF INTERNAL INFORMATION SYSTEMS

The current status of management information systems is remains dynamic. Several adoption surveys and personal experiences lead to some interesting observations. These observations will be reviewed in the context of a decision support system as defined by Spraque and Watson.

On-Farm Information Systems -- Computer Hardware

The percentage of farms owning a computer continues to grow. Most commercial farms now own a computer and have access to the Internet, many with high speed connections. Most of the computers are of recent vintage with large data storage and memory capacity. It is safe to state that the hardware is not the bottleneck with respect to management information systems.

On-Farm Database and Modelbase Applications

The decision support system literature stressed that the database and modelbase remain separate entities. They should be bridged by the database/modelbase management system. In examining much of the software developed for on-farm usage, it appears that most of it does not currently employ this design concept. Indeed most of the software is a stand-alone product with the database an integral part of the modelbase. However, some packages have the ability to export and import data, allowing for the sharing of data across the various packages, but these data sharing features are usually rather narrow in scope and flexibility.

The most common software packages used by agricultural producers are data oriented with the most common being one designed for financial accounting. Accounting packages explicitly designed for agricultural businesses and general business accounting packages are used for keeping the financial records. Because of their rather low cost relative to the agricultural specific packages, the general purpose packages are growing in market share. These financial accounting systems are used beyond completing tax documents. They are also important for providing information to creditors and for planning and control.

Production management also accounts for a significant proportion of computer usage. There are many software packages available that address livestock problems. Some are database programs to keep track of animal related data and/or feed inventories. There are models to address operational and tactical decisions such as ration balancing, culling decisions, alternative replacements options, etc.

However, many livestock producers also use off-farm production records processing such as using the DHIA service bureau for processing dairy records. These service bureaus provide a downloading feature so the data can be moved to the on-farm computer.

For cropping operations, there are similarities in software availability. Database systems are available for keeping track of information on fields and sub-fields, particularly fertilizers and pesticides applied, varieties planted and yields achieved.

Though there is increasing interest in geographic information systems by agricultural producers, the main usage is for yield monitoring and mapping. This approach is used to evaluate the effectiveness of alternative management practices employed in the production of the crop (e.g., comparison of varieties, seeding rates, pest control measures, tillage systems, etc.) and to identify field problems (e.g., soil compaction, drainage problems, etc.). This yield monitoring approach is finding the greatest acceptance and this may be in part because the yield monitoring and mapping systems are common option on grain harvesting equipment. One of the real concerns with using yield monitoring and mapping systems relates to the issue of arriving at the correct inference of what causes the variation in yields noted. The potential layers of data (e.g., pH, precious crops grown, soil structure, planting date, nutrients applied, variety grown, pesticides used, rainfall, etc.) has been suggested to exceed 100. To be able to handle the large number of data layers in an effective manner would suggest a full-feature geographic information system (GIS) might be needed. However, few agricultural producers have access to a full-feature GIS and/or training to utilize these systems, and there are substantial costs related to capturing and storing various data layers. Nevertheless, the more obvious observations originating from these systems (e.g., such as poor drainage and soil compaction) have resulted in sound investments being made in corrective measures.

To a limited extent, some agricultural producers are starting to make use of remote sensing data to identify problems related to the growing crop such as an outbreak of a disease. Those using remote sensing feel they are able to more quickly identify the problems and take corrective action, minimizing the damage done.

Precision agriculture applied to the animal industries is on a different scale. Information systems are playing a major role on the integrated mega-farms. When using information systems to carefully track genetic performance, balance rations, monitor health problems, facilities scheduling, control the housing environment and so forth, it is generally acknowledged that it is possible to achieve a fairly significant reduction in cost per unit of output (10-15%) over that of more traditional, smaller farming operations. These are proprietary information systems and the information from these systems are used to gain a strategic competitive advantage.

Lastly, the general purpose spreadsheet is the most common software used for planning purposes. Some of these applications are very sophisticated and address complex problems.

User Interface

The user interface has improved in greatly in quality. Most agricultural software now uses the windowing environment. This environment makes it easier for the user to use and access data and information, and to move data from one application to another or to link applications. However, this still remains a user-initiated task and in some cases can be complex. Also most of the data contained in the software package is unique to that package and not easily shared with other software packages. Thus, from a DSS viewpoint there are still significant shortcomings.

The Decision Maker

An often overlooked component of a decision support system is the decision maker. Prior surveys suggest that the primary user of the on-farm computer system is the farm operator. Operators that are younger and college educated were much more likely to routinely use the computer. Also large farms were more likely to utilize a computer in their farming operation. It is also observed that there is a fair amount of "learning cost" related to use of on-farm information systems. These cost can be large enough to hinder the adoption of management information systems.

CURRENT STATUS OF EXTERNAL INFORMATION SYSTEMS

There is increased interest and excitement about the role external information systems available to agricultural producers, particularly Internet and satellite data transmission systems. Each of these technologies is a vast resource of data which can be used to enhance the various levels (e.g., information, intelligence, knowledge, wisdom) of Haechel's Hierarchy for an individual or organization.

Another information source is the outside advisor. As the complexity and breadth of the farm level decision process has increased, the use of consultants and advisors has grown. This is particularly true of the larger farming operations.

Internet

The growth in Internet is phenomenal. The growth in its use by agricultural producers is also phenomenal. Email is a common communication tool used by agricultural business. The same is true for the world-wide-web (WWW). They made extensive use of the web to find information that fit their unique requirement. Even though they find it a major source of information for their operation, it takes good skills to locate the information desired. One of the common complaints is the amount of time it takes to utilize the Internet effectively and the lack of depth of information. One of the critical questions relates to how effective Internet is in addressing the higher levels of Haechel's hierarchy.

Other Internet resources available to agriculture include sites for downloading agricultural software. Much of the economic data compiled by the government is now available on-line. Lastly, in some cases it is being used as a marketing tool for products produced by the business.

Satellite Data Transmission Systems

The satellite data transmission systems are widely used by producers. These systems are passive data acquisition systems from the user's viewpoint. Data is continuously broadcast to the leased data terminal from a satellite. The data is automatically stored in the data terminal and can be accessed by a menuing process. These systems provide current data/information on a number of topics. Amounts and types of data/information received depends upon the options purchased. The basic subsystem provides for the latest market prices and news, weather maps (e.g., rainfall, jet streams, severe weather, crop soil moisture index, soil temperature, air temperature, etc.), government reports on market developments, long- and short-term weather forecasts, political developments that pertain to agriculture, and product information. Premium service options add even more features.

Outside Advisors

Several recent studies suggest that use of outside advisory services by farmers to enhance and supplement their on-farm information systems was fairly prevalent. The tax preparer is the advisory most commonly used. Other important sources of information include the local Extension agents, veterinary consultants, accountants, crop/pest management consultants, and livestock management advisors (e.g., a nutritionist).

The outside advisors utilize many different software packages to help provide advice to producers. FINPAK developed by the University of Minnesota is an example of a software package widely used by outside advisors with farmers. This financial analysis and related projection package helps evaluate the financial process being made by the farm and compares alternative future business options. This package (an accounting type model) is widely used in the U.S.

THE FUTURE

Predicting the future is not an exact science. But with the structural changes occurring in agriculture today, the management problems are significantly different from the problems of yesterday. Earlier emphasis in information systems was on improving production management decisions. Today, major issues that are commonly faced in management relate to financial, human resource, and marketing management. These management areas and their importance are identified in the strategic management workshops I have conducted with agricultural producers. Thus, managers will have less time to address production issues because more time and effort are being focused in the other management areas. This will have an impact on information systems to address production management.

Addressing Structured Decisions

In the future information systems to address production management will likely be of five general types: 1) software for systems analysis, 2) theory testing, software for teaching purposes, 3) software for advisors, 4) software for use by producers, and 5) software to control and monitor the supply chain.

Software for systems analysis and theory testing will be developed with the primary objective of defining the structure and studying the dynamics and interaction of the various system components. Its main use is in research. These models are fairly complex and often have robust data requirements. Their utilization often depends upon availability of the developers to run the model or assist in the use of the model. This software is very useful in testing various hypotheses regarding system dynamics (e.g., would supplemental irrigation in the early growth stages greatly affect yields?)

These models play a vital role in generating a better understanding of the overall system and can give valuable insight on how to manage the system. They are also useful in identifying areas for further research. The results from these models are communicated in various ways (e.g., journal articles, trade journals, and advisory service publications and conferences) and these communicated results are often used by producers to adjust production practices. However, direct use by producers to evaluate their own unique situations is not common with these models. There are several reasons for this limited use including a poor user interface or lacking the data to drive the model. Also, it is generally unlikely that transformation of a model of this nature into one that is to be used by the producers will be successful.

Software developed for teaching purposes is likely to continue. Sometimes these software packages are referred to as simulation games. Because these models teach concepts and principles, they are often a simplification of reality. They tend to use the case analysis approach, making it difficult to use the model to analyze various options and alternatives utilizing actual business data. The models are often used in an interactive mode (e.g., in a classroom or workshop environment) where knowledge is gained by testing "what if" questions, then observing the results. These models can be very powerful teaching tools, but are rarely used to analyze actual business situations. Producers often lose interest in using this software because it is too simplistic, takes too much time and effort to extract knowledge for better decision-making, or it does not adequately reflect the reality of the business.

Software for advisors is a class of software that is used by agricultural advisors (e.g., Extension staff, consultants, and agribusiness firms) to assist producers in making decisions. The advisor is a necessary intermediary, because the software could demand a thorough understanding of a difficult set of concepts (e.g., long range planning) or it may be rather demanding of the user's time and effort (e.g., a large amount of data has to be collected, entered and analyzed), or the time and effort to become proficient in the use of the model is considered excessive. This type of software will grow in importance as the use of outside consultants and advisory services by agricultural businesses grows. These outside advisors and consulting services will increasingly use many different software packages to help provide advice to the producer. The package they use depends upon their area of specialization. For instance, those that are offering production advise may use one of several production decision aid models.

Advisors also serve as an intermediary to extracting information from Internet (external data). They often subscribe to threaded discussion groups. They use these groups for posting problems and receiving back suggested solutions. They also learn from the exchange of ideas between others using the system. Also, advisors more readily see the merit of using a software program designed for systems analysis for enhancing their personal knowledge and skills and solving problems for their clients. This is particularly true if the software has a good user interface.

Software for use by producers is and will continue to be some of the most demanding software to develop. As indicated earlier, a large amount of software has been written, but much of it has fallen short of expected usage rate. One reason is the decision makers have found the software fails to address their problems. The software must be fairly easy to utilize, and the producer expects it to provide information that has a perceived value greater than the cost of attaining that information.

Software being used by producers can be grouped into two subcategories. The first subcategory is used to process transaction data and meet regulatory requirements. These are the software applications most used by the actual businesses. They must keep accounting, personnel and crop production records (e.g., pesticides used) because of government regulation. They also use software to reduce the time, effort and cost of processing the transaction records. This is why payroll packages, and shipping and billing systems are commonly employed on these operations. This usage will continue to grow in importance.

The other subcategory of software is used for management purposes. This currently accounts for a lesser portion of the computer usage. A large growth in this usage of this software is unlikely. The time and effort to master this software is major commitment. Since management time is being diverted to areas other than production management, they will have less and less time to become proficient in the use of this software. Thus, very thorough and sophisticated systems (e.g., the SAP software system) currently being employed by large companies are not likely to be common on farm businesses because of their complexity and cost.

Software for process control is used to control and automate many of the structured-operational decisions of the business enterprises, such as controlling temperature, light, irrigation and fertility in greenhouses. These models are generally of a closed-loop optimal control design. The process control models are generally knowledge based systems and have been developed using knowledge from many sources including the systems analysis models discussed earlier. The use of process control systems will grow in importance and acceptance. This acceptance implies that the managers have confidence in the models and that they improve the efficiency and effectiveness of the business. These models also free them to concentrate on more complex decisions.

Software to control and monitor the supply chain will greatly grow in importance. The will be many factors driving this grow including concerns about food safely, country of origin labeling, organic foods, foods to meet special dietary requirements, and concerns about product liability suits. In will likely become commonplace that a food item purchased by the consumer at the retail level will have attached its entire history, including identity preservation and traceability, included with the purchase. The new advances in RFID chips and the requirements by certain major retailers to label all products with these chips will impact agricultural businesses including those engaged in producing farm products. The system imposed upon the entire supply chain will likely be designed by the retailers and the entire chain will need to adjust to the defined information structure. To adapt to the defined information structure may mean a major restructuring of the information system currently being used by the business with substantial costs associated with the conversion.

Addressing Ill-Structured and Unstructured Decisions

To address the management areas related to human resources, finances, and marketing, suggest information systems that can address ill-structured or unstructured problems. Some would state that we are in the process of moving from the “old economy” to “new economy.” With this paradigm shift, among the changes is a movement from resource based to idea based wealth creation, from a stable comparative advantage to a dynamic one, from investment in physical assets to investment in human capital, from protected to open markets, from subsidies to encouragement to adapt, from hierarchal organizations to strategies alliances and partnerships. In addition agriculture will move from commodity markets to product markets and it will become more environmentally friendly, concerned with food safety, and quality and supply coordination.

If this transition from the "old economy" to the "new economy" occurs for agriculture, then the information systems of the past will not be adequate for the future. They will need to be much broader and more comprehensive than the current systems. The future systems must:

- address the larger scope of financial management rather than financial record keeping, tax reporting, and analysis;
- help define marketing strategies and alliances;
- help identify potential niche markets rather than supplying data on current commodity market trends;
- support the creation of new ideas;
- nurture the growth of knowledge since this will become a major source of wealth creation;
- deal with the many dimensions and complexity of human resource management;
- signal needed production changes in an overall system of supply chain management;
- assist in negotiating contractual arrangements;
- help the producer adopt to an economic climate that has more risk and uncertainty because of less government intervention in markets;
- provide the capacity to track the identify of a product from its genetics to the consumer;
- assist in producing a product that meets customer desires rather than the production of a commodity.

Developing farm-level information systems to fulfill these needs will be a major challenge. It will take a major rethinking with regard to the role of management information systems. It will involve more than enhancing hardware, communications infrastructure, and software components of the information system. An equally important consideration will be the analytical skills, knowledge, wisdom, and interests of the agricultural decision maker.

The information system of the future will need to concentrate more on the upper levels of Haechel's hierarchy -- knowledge and wisdom. As Honaka and Hirotaka observe, knowledge has two forms, tacit (subjective) and explicit (objective). Tacit knowledge is gained from experiences and practice, whereas explicit knowledge is based more on theory and rationality. As decision makers address problems, they convert knowledge between the two forms. An information system that focuses only on one form will have shortcomings. The information system of the future must have both forms of knowledge, and encourage the conversion of knowledge between the forms as a continuous process. Only by this process will the manager's knowledge base grow in size and function.

Information systems of the past have tended to concentrate on explicit knowledge (e.g., linear programming to balance a ration) and, to lesser extent tacit knowledge. Many of the problems of the future will involve tacit knowledge. The challenge will be designing information systems that will allow for an easier and more effective means of sharing tacit knowledge. The Internet will no doubt play a key role in meeting this challenge. Perhaps a system for documenting experiences (e.g., structured case studies) can be used to enhance the sharing of tacit knowledge.

SUMMARY

Agriculture has a long and proud past history in applying information systems including farming operations. Although there have been significant strides forward in improving the decision making of farm managers there are still areas for improvement. The decisions of the future will be different from those of the past. There will be no quick and easy solutions on how to design the farm information system of the future. Indeed, each farm business will likely have its own unique system that has been tailored to meet the special informational requirement of the farm business and address the needs of the entire supply chain. Those that are able to build and effectively utilize the farm information systems of the future will have a strategic advantage over their competitors.

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