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Decision Support Systems For Agriculture And Rural Futures

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For Agriculture And Rural Futures

by

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Abstract

The author's perspective about the managerial environment in the information age begins the paper. Access to and assimilation of knowledge in order to create data of high potential informational content is of substantial importance regardless of the nature of the firm managed. The future will require even more emphasis on information and knowledge in the conduct of managerial affairs. Management, as a problem solving process, requires a structure within which one can attain desired ends from available means. A decision supporting management information system (DDS) provides part of that structure. The primarily closely held firms of rural America, farm and non-farm, need computerized components to those information systems which work across management styles and related concerns. A prototype DDS for a farm is presented. Similar systems for main street businesses and for supporting professionals will be common. The prototype is modifiable as new applications become available and new problems are perceived. Many applications will have a heavy emphasis on both planning and on the technical management considerations of controlling the ongoing business. Data capture components which are equipped to do modification analysis of exception rules are a necessary component of such systems. Raw data components which are able to capture and distill the noise out of the accessible data bases according to managerial perceptions of problems are also required.

Introduction

This paper is about the future styles of and tools for management of the firms that produce our food supply. It begins with an overview of this author's perspective about some key elements of the physical and social environment within which managers operate. It describes how managers function and the nature of the environment within which they conduct their affairs as they manage themselves and their enterprises.

The second section continues by reviewing some useful concepts about the insights drawn from the information and management sciences. These concepts are then used, in a third section, to project how the development of decision supporting management information systems will be used by firms in the food and fiber sector.

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The Author's Perspective

Managers influence the future. Things do not just happen. Though many things are uncertain, the actions of managers and the conduct of their affairs do affect the shape of future events.

The Information Age

We live in an information age. But it is also a time where we are exposed to far more messages than we can digest. We usually consider many of these messages to be mostly "noise". A substantial challenge to each of us, both as an individual and as a manager of at least our own affairs, is how to filter out from all these messages that which is "potential information" in the information sciences sense. The next section will clarify what is meant by potential information. For now information can be thought of as knowledge which seems relevant to a perceived problem.

Information and Knowledge

Managers operate in a environment where knowledge is a critical, if not the most critical, resource they manage. They need to have timely access to appropriate knowledge in a rapidly changing environment. After all, in this world change is normal. It is stability that is not.

Knowledge is both personal to a manager and a social good of the firm, organization and/or the public as a whole. Knowledge is a resource which grows in value if it is shared. Institutions like schools, libraries, and the media share knowledge between people. As Harlan Cleveland pointed out in a 1989 essay in the Minneapolis Star Tribune, there are many attempts to keep some knowledge in the private sector as a proprietary commodity. There are many social difficulties with the idea of proprietary knowledge from society's viewpoint.

While it may be appropriate that the delivery and service of certain structured components of the knowledge base be a profit oriented enterprise, it is difficult to see how the basic knowledge itself can be of most use to society if it is not shared. Knowledge grows by being shared. Learning occurs through sharing. Sharing is the relationship between learning (a flow process) and knowledge (a stock resource). It is also a process whereby management teamwork becomes effective.

Management and Productivity

Managers operate in a worldwide competitive environment. Our rates of productivity increase in most economic sectors, though perhaps less so in agriculture, has lagged behind the rates occurring in a number of other countries. Access to knowledge of many kind - science based technology, price data, institutional structures, and knowledge of human behavior, to name a few - is necessary to be competitive in today's world.

Concepts from The Disciplines

For example, the following basic insights about the world are drawn from the author's parent discipline of agricultural economics. (1) Demand is inelastic for basic farm commodities; prices change more than

weather influenced supplies do. (2) Marketing margins are sticky; they increase as prices go up but stay the same as they decline. (3) The biology of production and delays in producer response to market price changes leads to cycles of production for livestock. (4) While governmental interference may dampen the effect, the markets approximate price competitiveness for most of agriculture. The corollary to that is that pure or monopoly profits are hard to come by at the producer level. (5) The internationalization of markets reduces price control by either traders or governments. There are many others.

These and similar insights from many disciplines are vital knowledge to managers. They summarize a world view within which strategies are planned, carried out and evaluated.

Knowledge Acquisition Has Its Costs

Access to knowledge is costly because of time costs and the other resources associated with its acquisition. There is a tradeoff for a manager between taking the additional time to acquire more knowledge and the cost of the delay caused by doing so. The management time associated with learning can have a high opportunity cost. There can be a major cost to a busy manager in either avoiding or dealing with delay in biologically based production processes.

Related Management Science Concepts

The management sciences are developing structured approaches to the storage and acquisition of knowledge. The objectives are to both reduce the cost and to enhance the usefulness. Through the processes of computerized database structuring and design, as well as the more traditional approaches of library type categorizations, much has been accomplished over the last several years in offering potentially useful structures to the storage and acquisition of knowledge.

Meanwhile other work continues to assist managers in problem definition and clarification. Quantitative methods are refined to deal with well structured problem components. Artificial intelligence or expert system approaches are explored as ways to deal with poorly structured components. Data base structures and retrieval techniques are designed to match analytic approaches to available data, problem perspectives and managerial style. They are also being redesigned to increase processing efficiency and to reduce the need for technical assistance, maintenance and structure in their use. The thrust of these efforts is to make all these approaches complement one another.

A key challenge to workers in the management sciences is to design systems that managers can and will use. The system(s) must meet high standards of capability to be easily learned and used. They must be quickly and easily able to filter out receiver determined noise from a variety of messages in ways to enhance their potential informational content. Managers vary in style and in problem perspective. Both complicate the task of the designers of such systems.

Time plays several important roles in design and in usefulness. For some data, the value decays rapidly. Time to act may be related to the time of collection. Schedules may limit the time to analyze the available data. For many of us "control of our destiny" requires the ability to time shift the filtering and receipt of selected messages to better match our individual time schedule. Only then can we adequately prioritize them and their influence on our lives.

Management is Problem Solving

The practice of management is problem solving. It is both an art and a science. It uses all of Royce's ways of knowing. It, like many other affairs of people, will continue to do so. The mix of the two in use by practitioners of management is termed "management style". Goal and/or objective setting is primarily based on the pathways to knowing termed by Royce as authoritarianism and intuitionism. However "ground truth" realism is often added through using the approaches of empiricism and rationalism as well. Problem solving requires knowledge of the current state of affairs, the ground truth of reality such as was expressed in general terms in the first section.

Strategic planning with its emphasis on "futuring" and long run and "megatrends" is a good example of both the art and the science. But when the emphasis moves towards the analysis of investment alternatives, the mix changes somewhat more towards the normative use of science. Tactical and operations management, with its emphasis on implementing the plan, on control, adjustment, and supervision, can vary a great deal in the mix used. Certainly elements for which knowledge is sparse or does not exist or is too costly to acquire requires more art in management.

The Problem Solving Process

In many business enterprises, the science component increases in importance when it becomes competitively necessary to increase access to and to use existing knowledge bases. Filtered information derived from the content can help the decision process which lies at the core of management.

The problem solving process is described by various authors. Following Dewey, it includes;
(1) problem definition and clarification as a first and often a revisited component during the process. Given a problem definition it also includes (2) specification and (3) analysis of the two or more alternative courses of action available. Then (4) selection of a course of action is required. Implementation (5) or follow through based upon the selected course of action if management is to have positive impact. And concurrent with that is the (6) associated bearing of the related responsibility for the results both good and bad. Even then the process is not finished in the rapidly changing environment of today. Review (7) and learning based upon what has occurred and its influence on further conduct of the process is required for effective management. Creative management requires sufficient attention to this step to capture and retain the experiences necessary to better meet future challenges. Well designed information systems can assist learning by what, when and how this capturing is done. Problem solving may require looping back from any step in the process as the need arises to re-clarify the problem or the feasible alternatives.

Decision Supporting Management Information Systems

Every manager has a management information system (MIS). A computer is not required. The MIS may be completely informal; entirely in the head of the manager. Formalization begins whenever notes are recorded in the belief that their later review will provide information of use as future problems are addressed. Greater formalization usually leads to putting some components into a computerized system. But no system is without some informal components. What and when to formalize more components is an interesting economic and management style question. Size and type of firm structure play a role in analyzing it. Farms, for instance, require some unique components for the reasons sketched out in this paper. (See the schematics appended)

DDS Design Guidelines and Focus

The content of any substantial multiple purpose MIS data base is a mixture of noise and data of potential informational content (or messages) when seen from the perspective of a specific problem. Accounting records contain little, for instance, of use for inventory control or forward planning.

Because more is involved than just data recording and retrieval, newer designs often carry names like "Decision Support Systems" (DSS) or "Executive Support Systems (ESS). The challenge, regardless of name and implied function, is to design them so that they actually will assist managers of varying styles, concerns, and interests when they are faced with yet to be defined problems.

It is necessary to filter the data content in order that the noise is reduced and the result is the distilled potential information useful to the receiver; the manager. This means that when the maintainers of such systems (writers of market news, Extension Services, electronic bulletin boards, etc.) often classify the many messages several ways or use key words. They still need to be conscious that the ultimate filter of the message will be the receiver-manager. It is unwise to say to a manager that "I have some good information for you"! The filters are dependent upon one's perception of problems, their magnitude and their importance to the receiver.

These systems must have the ability to capture and retrieve data in order to timeshift the final assimilation of some messages according to the schedule and workload of the manager. This will require creative development of new and improved procedures to help with the filtering. This includes procedures to quickly search through several poorly structured data sources. The intent would be to improve both the definition of and the evaluation of alternatives to deal with what the management sciences term as "poorly defined problems".

Managers differ in style and information needs dependent upon what they are trying to manage. There is a uniqueness to an individual manager's approach to problems. Whenever members of the management team allocate responsibilities by function, that too will influence each of their specific interests, concerns and use of a MIS/DSS/ESS.

Structures provided by those working in the information sciences should have the ability to be modified or adjusted by the individual manager. While the structuring and analysis are both science based, a component of management as art remains so long as one is attempting to improve the ability to use all available means to attain a specific set of desired ends.

DSS Use in Agriculture: The Future

Agriculture produces biologically based products. This means that weather and an environment where worker mobility is required shape the supervisory and tactical components of the management task. Time scheduling is a challenge. The worker must go to the work when it is time to be there.

At the farm level, a price competitive market system with many other producers is usually the case. Sources of risk and uncertainty in both prices and production performance, not to mention all the other sources commonly observed, are the norm. These factors will have major impacts on firm size.

Most firms employ few if any people who are not also part of the management team or the producer's family. Small group co-worker communication from scattered sites is a major human relations challenge to a manager.

Most of the service and supply firms in the sector, while having a somewhat larger work force, still are small by industrial or commercial standards and present managerial challenges which have attributes similar to farms as a management environment. Movement of workers to scattered locations, for instance, is a common feature. Some greater specialization of employees is noted but multiple roles are common.

In both cases, a manager will have a variety of matters calling for attention besides information management. While accounting work may be delegated to others, that is the likely total of specialized "knowledge workers" in the firm.

Hence limited time to manage information will continue to be the norm. Operations managers will continue to be primarily action oriented just as they are now. But attention to and discipline for insuring data capture will be required by economic and institutional forces. Even as competitive pressures build to manage data and information, most managers and other users of a computer based information and/or control systems will continue to be "occasional users" as the term is used in software circles.

Systems designed to meet the diverse needs sketched out here of agricultural managers are even now being developed and tested. Similar systems to meet the needs of consultants and educators who offer staff support to the operating managers are also being tested. Both groups will view information management as an integral part of their operations. Both types of users have similar needs and time pressures.

The Resulting DDS/EMS/MIS For Agriculture

We are discussing systems which offer menus of processing and analysis options. These systems will contain much more than record keeping systems. They will contain formalized control systems for high technology enterprises such as dairy or swine husbandry. Much data capture will be automated. Early alert messages will be triggered by manager specified management-by-exception rules. Irrigation and plant pest protection schedules will be driven by these systems. Prototypes now exist to do similar things to what power plant control panels now do. Fertilization rates will be adjusted "on the fly" by on-board computer systems responsive to soil, weather and growing conditions. Economic computations to these adjustments will be integral in the future.

Aerial photographs or other remote sensing will provide digitized data concerning field conditions on a regular basis during the growing season. Truck operators will capture load weights automatically with on board electronic scales. Farm managers will have real time access to weather and market data. They will also be able to reduce the detail retained to provide an appropriate set for longer range more strategic usage.

The systems will allow inclusion of management-by-exception rules to offer early alerts concerning factors needing attention. In some cases, automatic activation adjustment of control devices will change the ventilation of a facility or the quantity of a feed ingredient "on the fly" without operator intervention.

Components of such systems are currently in use in feed plants, livestock operations, green houses and irrigated crops. The next step should be the addition of statistical analysis components to quantify additional components and to formalize the system's capacity to assist the learning element in the decision process. That will also be the basis for improving the underlying understandings of the related production processes. The underlying biology of growth and change makes this a complex challenge compared to

many industrial processes. Parenthetically the University of Minnesota systems known as PIG CHAMP and DAIRY CHAMP have now captured a sufficient data base to permit the research exploration of many facets for those industries.

Another major challenge concerns the search for and retrieval of data from diverse sources, and specified in different forms, at the command of a manager-user within the previously indicated time limitations so as to make it useful on the problem at hand. So long as creative activity occurs, new structures, analysis procedures and uses will arise. Integrated software will help. But more robust procedures will always be required as long as there are qualitative elements to work with in poorly structured problem situations and creative managers dealing with them!

The selected retrieval of topical literature and research reports at the manager's discretion will deserve special attention in the future in such firms as well. The development of CD ROM technology and/or its equivalents, along with software which can rapidly extract items of interest, will play a major role in the development and utilization of such systems. Already in existence are substantial though still partial data bases of use to learn about many things that managers want to know. With them, managers can quickly determine the existence of available research based data related to concerns that they have. They can also discover the impacts of institutional regulations and limitations.

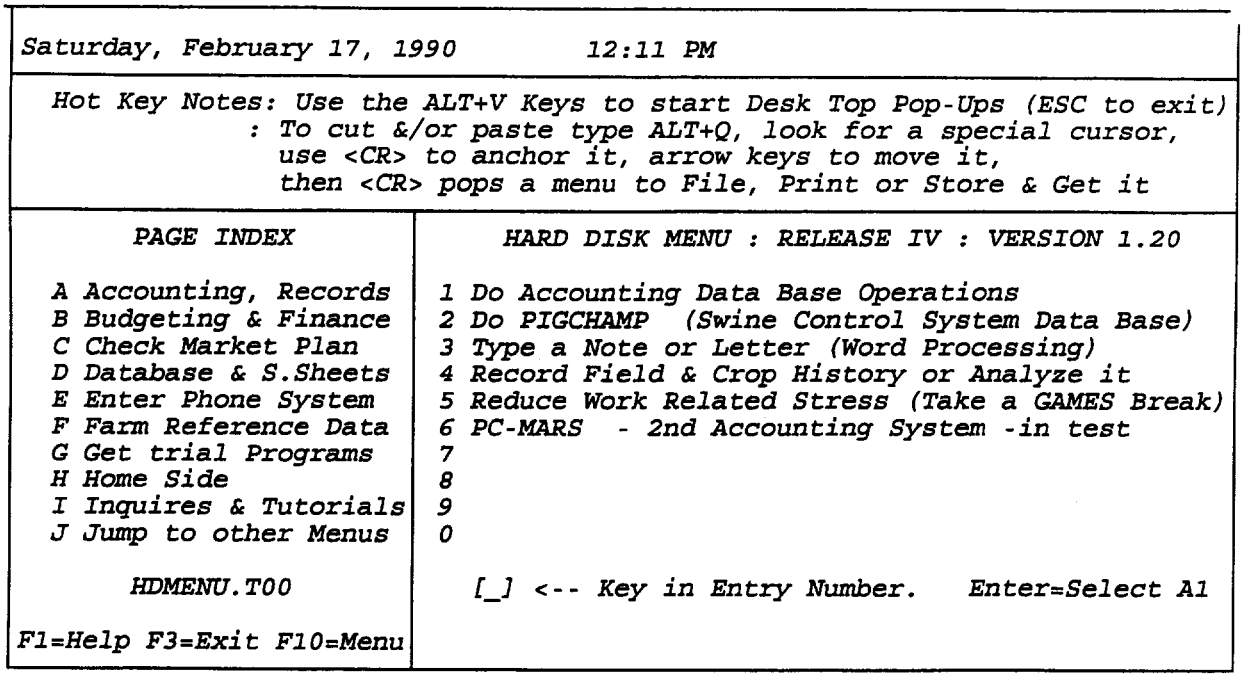
They will have access to vendors, markets and the ability to monitor activity in the world around them. Already in existence is FM radio transmitted market services which are displayed screen by screen on a specialized system. Well-filtered components of such screens will be captured automatically for later assimilation and analysis. To do so is to follow the notions of time shifting and final filtering to permit the analysis to conform with the manager's time schedule and interests.

The future will see the integration of these components and the data bases underlying them in ways to assist the general manager to a far greater degree than is currently the case. Easy to use and modify menuing software will be a major integrating component. Questions concerning the best structure and branching techniques exist. Background software tools to assist in finding and transferring data as well as common desktop applications also raise best structure issues. Graphic presentations will be used when they can either speed operations and assist comprehension. Multiple entry and query points with automated entry capability will be common.

Prototype Examples

One screen from a many screen prototype of a controlling software system is shown below. This prototype is, in specific situation or firm modified form, now in use on several farms. Similar prototypes exist for elevators, rural main street businesses, and for use by field staff in Extension. See the Appendix for diagrammatic representation of the useful features of such systems.

Illustration Of A Typical DDS Menu Screen



Note the three major features of this menu screen. At the top is a set of user notes concerning how to access background utilities at any time. Included is the capability to cue and paste data from one application to another.

The "page index" is an up to ten page tree branching system to sets of individual choices in each branch as illustrated on the right side. Users can modify this structure at will. Up to 100 such menus may be included.

Perhaps some examples will help. Near Mountain Lake, MN, there is an extended family swine farm which actually uses seven on-site computers regularly. Their first one, purchased over ten years ago, is completely obsolete. But, it paid for itself within two years by being part of a better control for the hog operation. It now is used as a desk where its replacement sits.

Another computer is a specialized process control unit which monitors and controls the swine housing ventilation and the feed grinding, mixing and distribution systems. It permits them to use a 24-hour low volume, low energy requirement feed grinding and pelleting system. Because it does, the savings and investment in a milling system pays for a substantial amount of the investment. Two other systems are essentially personal computers for the managers themselves. Another is used by the accountant. Another is usually tied up by a part time college student programmer doing developmental work in improving the other on-going software systems in use in the operation. Some, if not all, systems are networked together such that data can be readily transferred between them. This becomes particularly useful in that, while a swine herd control system computer captures data, their interest on this farm in analyzing that data is well beyond that found in many operating businesses. The data is regularly transferred from the swine control computer to the one used to do such analysis.

Another example is a farm using the prototype illustrated by this paper. They grow over 1200 acres of irrigated crops. At this time, the primary use is in accounting data capture and analysis. The data is transferred to a university computer for analysis and for comparison with other like farms. However, in the process of accountancy, there is a substantial need for employee records, including the annual preparation of some thirty to sixty W-2 forms. A vegetable packing operation is part of the business. Income tax management and planning is a necessity, an important application on farms faced with varying market conditions that such an operation sees.

The next step will be the addition of another computer which of necessity must be portable. Its major use or application will be in capturing in more or less real time the performance of the 12 central pivots which irrigate the crops. In dry periods, irrigation is a 24-hour a day operation. The reason for the portability is so that the manger-employee-family member who is on duty to see that these systems are operating correctly can do so by intercepting radio transmitted messages from each of the systems and ascertaining its current status. With the inclusion of an alarm system, this will permit a minimum of interrupted sleep or other activity. The software and radio units they plan to use are already in place on other farms with similar operating conditions. The software are a joint development of a private company and the USDA.

As experience grows in such environments so will interest and even a broader scope of application. This is what encourages the utilization of systems as described in this paper.

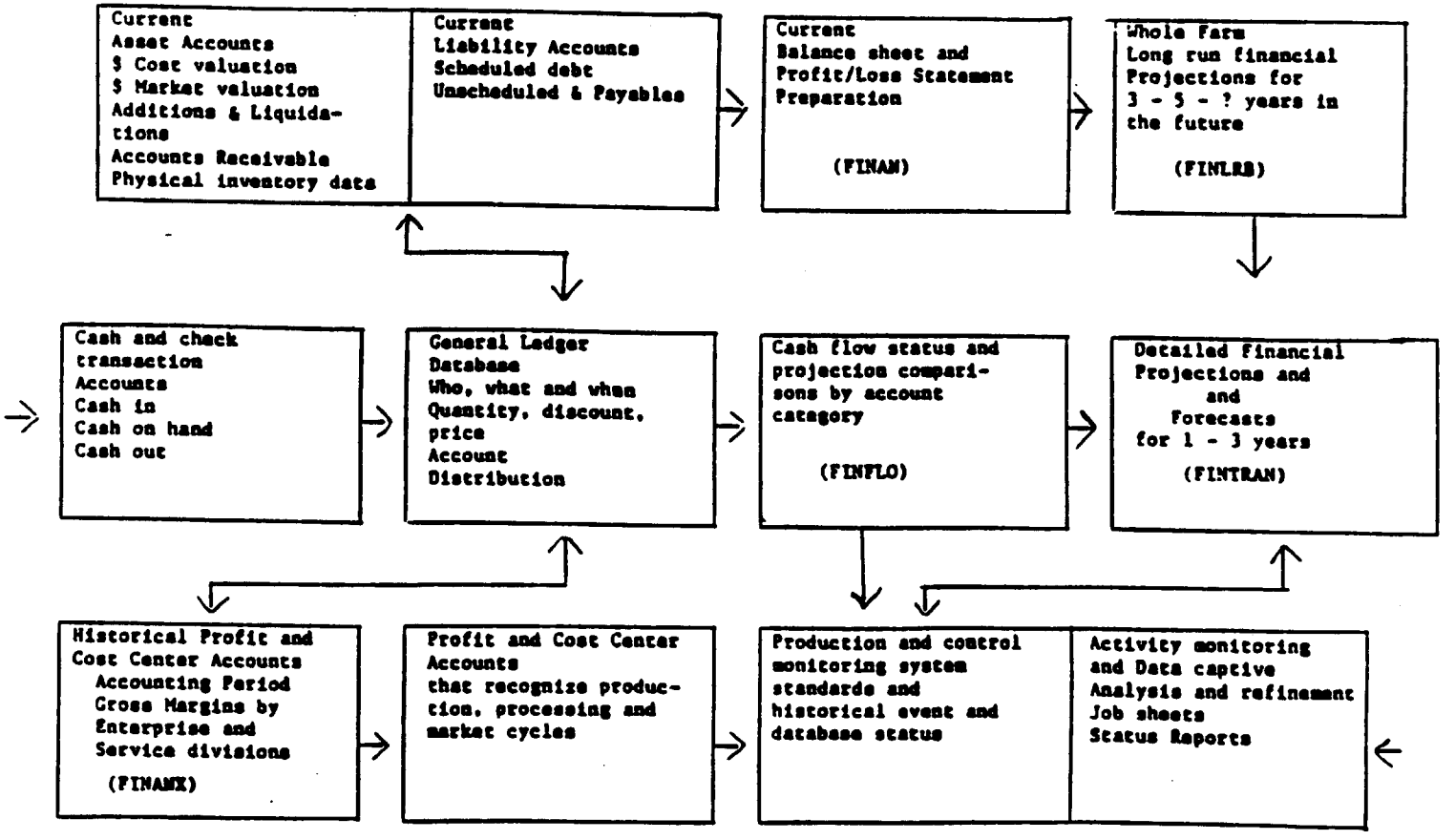
Impact on the Organization of Agricultural Production

Will the use of agricultural information systems impact firm size and organization? They will increase the separation of management from labor as does the adoption of new technology generally. More total work force time will be required to manage. But is it these systems or is it the nature of technology and of market forces in the information age itself which does this? Perhaps it is the impact of much more comprehensive forces than the formalization of information systems which are at the root of the anticipated changes in firm size and industry structure.

The manager's span of control can increase with such systems or for some, life can be less stressful. But the basic forces of technology change, institutional structure and risk exposure are of far greater importance in influencing firm size. Still the system approach expressed in this paper is a management response to these forces. From the personal perspective of this author, a management educator working with farm people, the alternatives to the scenario outlined would contribute less to both the productivity of the sector and to the vocational and personal lives of the people who manage and produce the nation's food.

There are challenges to making this paper a guide to the future. They will be met. How soon and with what access by whom is one of the challenges. This is primarily the challenge of support and funding. Policies to create an appropriate policy concerning the public and private sector cooperation in the process is a challenge. The education of both managers and developers in the proper application of available technology and analysis is an even greater challenge. The public sector will provide models of excellence in content, of data processing and of equity in access to the contained knowledge.

A MIS - Integrated Data Base Perspective on the Keeping of Farm Records



(Schematic illustrates the relationships between the accounting system and the overall DDS including the financial planning system known as FINPACK from E. I. Fuller, Teaching Materials in Farm Accounting.)

REFERENCES AND RELATED SOURCES

Cleveland, Harlan, "The Folly of Refusing to Share Something That Can't Be Owned", Star Tribune, (Opinion Page 9A), Minneapolis, MN, 5-30-1989.

Davis, G.B. and Olson, M. H., Management Information Systems: Conceptual Foundations, Structure, and Development. 2nd ed. New York: McGraw-Hill Book Company, 1985.

Fuller, E.I., "A Profitability Perspective on the Further Development and Use of Formalized Dairy Farm Control and Planning Systems," Staff Paper P87-24. Department of Agricultural and Applied Economics, Institute of Agriculture, Forestry and Home Economics, University of Minnesota, August 1987.

Fuller, E.I., "Some Concepts and Definitions Useful to Agricultural Economists Working in the 'Informational Age'," Staff Paper P83-13. Department of Agricultural and Applied Economics, Institute of Agriculture, Forestry and Home Economics, University of Minnesota. June 1983.

Fuller, E.I., "Menuing Software: Application To The General Manager's Need," Department of Agricultural and Applied Economics, University of Minnesota, Staff Paper P90-25, March 1990.

Fuller, E.I., "Microcomputers: Useful in All of Agricultural Economics and Extension," American Journal of Agricultural Economics. Vol. 64, No. 5, December 1982.

Fuller, E.I., "Using Data Base Management Software To Formalize the Control of Swine Farm Operations," Prepared for presentation at a workshop entitled "On-Farm Computers," Purdue University, November 21-23, 1982.

Fuller, E.I., "Techniques to Formalize the Control of Ongoing Farm Operations Through Computerized Data Base Management," Paper presented at a workshop on "Computers in Agriculture," Rochester, Minnesota, March 1982.

Fuller, E.I. and Hasbargen, P., "Extension Time-Share Computing In Minnesota Today and Tomorrow," Prepared for presentation at a seminar on "Current Use and Immediate Potential of Remote Terminals in Extension Programs," VPI & SU, Blacksburg, Virginia. December 7-9, 1971.

Harsh, S.B. and Brook, R.C., "The Integrated Decision Support Systems Project At Michigan State University," Proceedings of the 2nd International Conference on Computers in Agricultural Extension Programs, Vol. 1, February 1988. pp. 121-126.

Harsh, S.B., "Decision Support Systems--Definition and Overview," Paper presented at the annual meeting of the American Agricultural Economics Association, 1987.

Holsapple, C. and Whinston, A., "Software Tools For Knowledge Fusion," Computerworld, April 11, 1983, pp. 1-9.

Horwitt, E., " 'DSS' Effective Relief For Frustrated Management," Business Computer Systems. July 1984, pp. 44-56.

King, R.P. and Sonka, S.T., "Management Problems of Farms and Agricultural Firms," R.J. Hildreth, ed.. Agricultural and Rural Areas Approaching the Twenty-First Century, Ames, Iowa: Iowa State University Press, forthcoming 1988.

King, R.P. and Shuker, I.G., "Strategic Responses to Changes in Information Technology," American Journal of Agricultural Economics. 69(1987): 1056-61.

King, R.P., "Expert Systems in Agricultural Management Decisionmaking," Paper. Department of Agricultural and Applied Economics, University of Minnesota, August 1986.

King, R.P., "A Decision Support System for Commodity Marketing Management," Staff Paper 85-37, Department of Agricultural and Applied Economics, University of Minnesota, December 1985.

Mawby, R.G. and Haver, C.B., "Types and Sources of Information Used by Farmers," G.L. Johnson, A.N. Halter, H.R. Jensen, and D.W. Thomas, eds. A Study of Managerial Processes of Midwestern Farmers. Ames, Iowa: The Iowa State University Press, 1961, pp. 24-40.

Mdhizou, M. and Fuller, E., "Some Theories and Concepts Concerning a Systems Approach to Management," Staff Paper P85-19. Department of Agricultural and Applied Economics, University of Minnesota, Institute of Agriculture, Forestry and Home Economics. May 1985.

Pease, J.W., Hilker, J.H., Black, J.R. and Hesterman, O.B., "Effective Extension Teaching Software: Lessons from Field Experience and Educational and Cognitive Science Research," Proceedings of the 2nd International Conference on Computers in Agricultural Extension Programs. Vol. 1, February 1988. pp. 710-716.

Royce, Joseph R., The Encapsulated Man, Insight Series, Van Norstrand Pub., 1964, 206 pgs.

Thomas, D.W. and Knight, D., "Analytical Process in Farm Management," G.L. Johnson, A.N. Halter, H.R. Jensen, and D.W. Thomas, eds. A Study of Managerial Processes of Midwestern Farmers. Ames, Iowa: The Iowa State University Press, 1961, pp. 55-84.

Wink, Laurie, "Will Computer Software Replace the Coffee Shop?" Futures. MSU Ag. Exp. Sta., Winter 1988. Vol 6 No 1. pp. 20-24.