INTEGRATED DATA AND INFORMATION SYSTEMS FOR AGRICULTURAL ECONOMIC RESEARCH IN THE 1990'S

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ABSTRACT

This paper provides a state-of-the-art assessment of an integrated database and information system for research in a university environment. It begins with a review of the innovation and diffusion of computer-based information technologies, then follows with an evaluation of three technological frontiers, and a demonstration of the importance of system integration. Implications of new information technologies are analyzed with respect to agricultural economic research. The illustrative example given is the integration of a database management system with an on-line and ongoing large-scale econometric modeling system. A broad spectrum of database management techniques are employed for a multi-commodity, multi-frequency farm commodity sector model of cotton used for ongoing forecast and interactive policy analysis.

KEY WORDS

Information Technology; Database; Econometric Model; System Integration.

INTRODUCTION

The annual meetings of the American Agricultural Economics Association have long provided an important forum for review and assessment of our agricultural databases and information systems. During the seventeen-year period following the release of the Economic Statistics Committee's 1972 report on "Our Obsolete Data Systems," agricultural data systems have been a topic for intensive research and publication. Among the critical issues that have attracted much attention are the long-standing problems of conceptual obsolescence of data, inappropriate statistical measurement, and insufficient data coverage (AAEA; Bonnen 1975, 1987, 1988; Stanton), as well as the emerging data issues associated with the effect of federal budget reductions on agricultural statistics (Just, Gardner) and public data needs for rural communities and the changing agricultural structure (Schertz, Knutson).

While the 1989 workshop is essentially a response to these data issues, a new dimension of this year's program is a technological assessment of the data and information systems by government,

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industry, and university representatives through the cosponsorship of the AAEA's Economic Statistics and Information Retrieval Committees. This cospornsorship of two committees suggests the AAEA's recognition of the complementary and inseparable nature of a data system and an information system. In an era of the microcomputer and "end user computing revolution," costs of data generation, dissemination and utilization are dropping sharply, while rate of returns on data investment should increase dramatically. It is obvious that advanced information technology, if properly adapted, should help facilitate innovative capabilities of our data and information systems and alleviate some of the adverse effects of federal budget reductions.

My assignment is to provide a report on the databases and information systems from university research perspective. However, I feel I should not restrict my presentation solely to technological assessment. In my presentation, I will first comment briefly on the current stage of information technologies and the process by which further development is anticipated. Second, I want to explore implications of this technological revolution on institutional changes and the technological infrastructure. Third, I single out "integration" as the most crucial factor affecting all the functional roles used with data and information systems. It also affects fundamental changes in agricultural economic research in both the private and the public sectors. Fourth, I will briefly describe an integrated data and econometric modeling system as an example to show the database and information processing requirements as well as the opportunities and risks associated with new information technologies. Finally, a few concluding remarks will be made.

INFORMATION TECHNOLOGY FRONTIERS

Important signals with far-reaching implications point to the need to begin with the highly technical topic of information technology frontiers. I would like to share with you my personal interpretation of these signals in order to stimulate further thought and discussion. A formal analysis is not intended for this presentation. The comments essentially reflect my background, experience and judgment with respect to the projected time path of innovation and diffusion of information technologies.

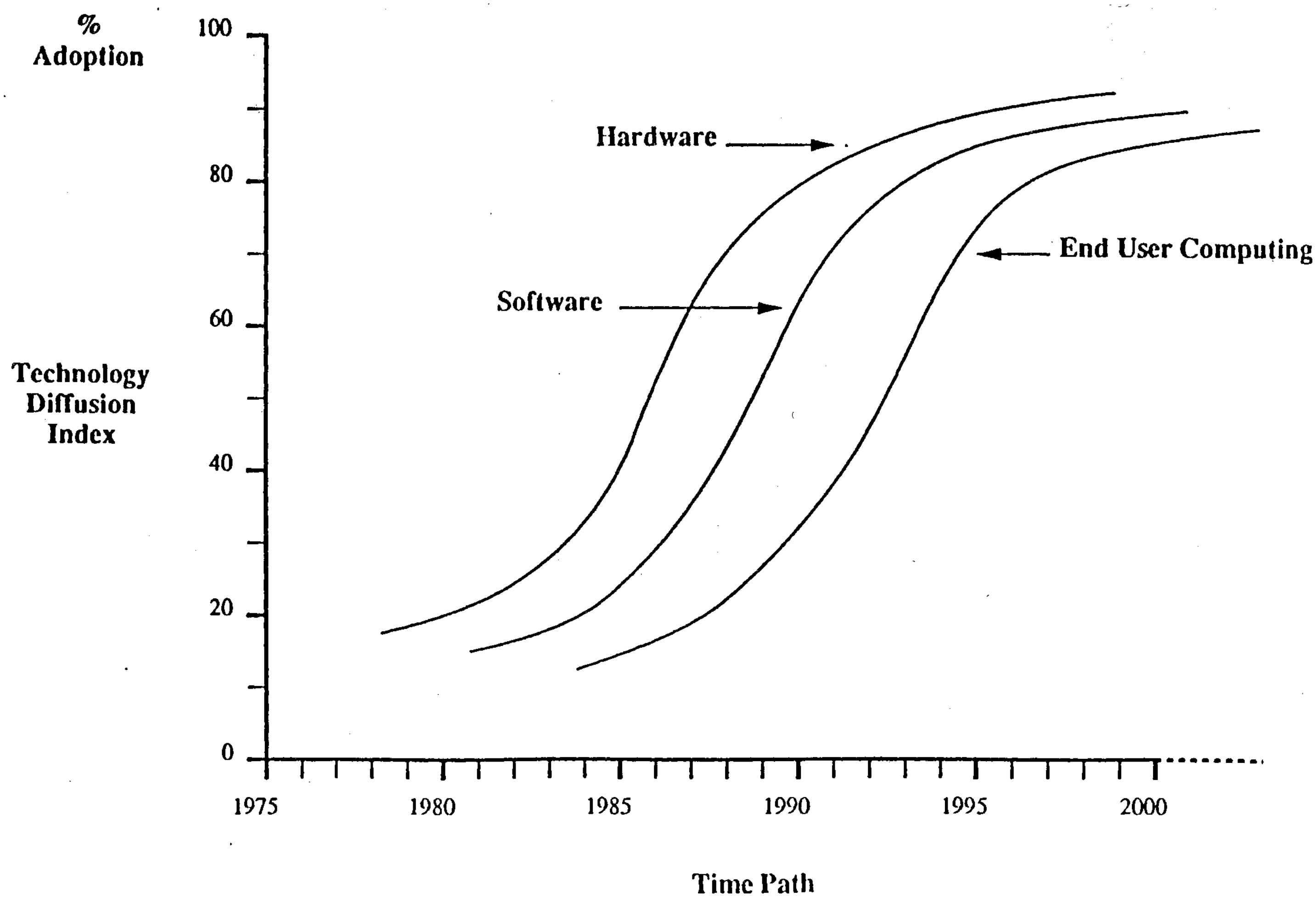
The great growth in information technology can be described by a three-stage process of technology innovation and diffusion: (1) hardware technology - the invention and evolution of microcomputers, telecommunication devices and other microelectronic devices; (2) software technology - the development of operating systems, high-level programming language, and application (generic) specific software; (3) end user computing (EUC) technology, including most or all of the applications that characterize the post-data-processing revolution, in particular the application (hybrid) systems and systems integration.

These processes are described with respect to each technological frontier using a simple S-curve to explain the time path of technological changes over a 25 year period between 1975 and 2000 (Figure 1). The S-curve representation is a simple and convenient method to illustrate the timing and behavioral patterns of the creation, distribution and adoption of information technology. The S-curve shows that the first phase of technology adoption is a slow growth period. In the second phase, new technology has developed to a standard design and moves into a period of rapid expansion in the market. In the final phase, the innovation rate slows and market adoption reaches its peak. This is the phase of technology maturity and the period of market saturation (Betz).

There are important connections between the processes of technological generation and diffusion of hardware, software and end user computing. The first S-curve demonstrates the introduction and diffusion of hardware technology, or the time path of early entry and adoption of microcomputers and other devices between 1975 and 2000. The second S-curve represents the development and diffusion of software technology with a time lag of 4-5 years following the adoption of hardware technology. Finally, the S-curve for end user computing represents the third technological frontier with another lag period of 4-5 years. A thorough comprehension of these three technological frontiers and their interrelationships, especially the underlying driving forces, is needed for the purpose of technology assessment and projection.

Since the mid 1970's the successful entry of the microcomputer has led to a rapid development of hardware technology such as the terminal for input, the tape and floppy disk for storage, the printer for hard copy, and the modem for communication. The time path of the hardware technology adoption curve indicates a period of rapid growth since the early 1980's that continues to rise strongly into the 1990's. Software technology follows a similar growth path,

Figure 1: <u>Generation and Diffusion of Information Technologies</u>



beginning its rapid expansion in the mid 1980's and rising exponentially in the late 1980's. Developments responsible for these dramatic changes include the standardized operating system and user interfaces, high-level programming language and, most importantly, applications software (mainly the generic applications, including communication, analysis, data retrieval and application, activity management and graphics).

The third technology frontier, end user computing, begins almost immediately after the successful innovation and adoption of both the hardware and software technologies. The introduction and development of the EUC technology is assumed to follow the same S-curve adoption pattern with a starting point in the late 1980's. The "third wave" of information technology represents a period of adoption of the EUC system applications, including applications on time-shared hosts, personal computer applications, nonclerical office automation, decision support systems and executive information systems. These application systems, as opposed to generic applications, are classified as "hybrid applications," requiring high level technical expertise and a high degree of integration.

In this new era, important shifts of priority in the use of computers are apparent. There are strong indications of increasing size, complexity and importance in EUC for the years ahead. An industry projection suggests that during the period from 1980 to 1990, total computer capacity will have increased 20 times, while end user computing will have increased 40 times and consumed 75 percent of all CPU cycles by the end of the decade (Panko). Clearly, changes are already well on the way, making EUC the dominant form of computing for the 1990's.

The recent innovation and adoption of hardware and software technologies has resulted in the building of a solid foundation to support the end user explosion expected in the 1990's. In this new era of information technology, much larger and more diverse application capabilities will be built. This represents a substantially different computing environment for research and development work in both the private and public sectors. In dealing with different types of EUC applications, it is important to plan and explore the different approaches; only then will we realize the full potential and ensure the successful management of EUC.

SURVEY RESULTS AND IMPLICATIONS

Based on the projected diffusion paths of the three technological frontiers depicted in Figure 1, the current stage of information technology points to a high adoption rate of hardware technology, a medium adoption rate of software technology and a low adoption rate of EUC technology in 1989. The projections reflect essentially my professional observations and judgment rather than a formal empirical analysis. However, the timing and behavioral pattern of the adoption of microcomputer and software technologies seems to be largely consistent with previous reports and research publications (Putler and Zilberman; Litzenberg; Dahlgran).

Important empirical evidence in supporting my projected adoption rates can also be found from the data priorities survey of the memberships of AAEA and other participated social science associations conducted and reported at this workshop by Hushak, Chern and Tweeten. Special tabulations of this large-scale membership survey regarding the characteristics of respondents and their alternative means of data access provide interesting insights into technology adoption profile on hardware, software and EUC technologies.

Two sets of statistics are selected for evaluating the adoption rates of survey respondents: (1) the use of a microcomputer by the respondents (Section III-9 of the questionnaire), and (2) means of current access to data sets (Section I-C of the questionnaire). The survey results are summarized in percentage terms below.

(1) The use of microcomputers by survey respondents

Do not use a microcomputer	7.9 %
Word Processing	83.0 %
Statistical Analysis	64.8 %
Spread Sheet Analysis	62.5 %
Graphics	55.2 %
On-Line File/Data Transfer	40.1 %
Other	8.4 %

(2) Means of current access to data sets

General Publications	45.0 %
Agency Publications	45.0 %
Floppy Disks	8.0 %
CD-ROM	1.0 %
Tape	17.0 %
On-Line	5.0 %
Other	2.0 %

The small proportion of survey respondents not using a microcomputer (7.9%) implies that a great majority of the respondents, 92.1 % are microcomputer users. This high usage rate confirms my projection of a high adoption rate of hardware technology as shown in Figure 1 for 1989. It is important to note, however, that the survey respondents are from a high-education and high-income population of participating professional associations of agricultural economists and rural social scientists. The adoption rate for this group of respondents generally is higher than the rate for the overall population of the agricultural sector and rural communities.

The survey also demonstrates relatively high usage rates of microcomputers for applications in word processing (83.0%), statistical analysis (64.8%), spread sheet analysis (62.5%), and graphics (55.2%), with a lesser usage rate for on-line file and data transfer (40.1%). The results lend support to the technology diffusion and adoption patterns shown in Figure 1, in particular the timing for hardware, software and end user computing frontiers, and their lead-lag relations.

Tabulation results on alternative means of data access by the respondents demonstrate that the top three categories are general publications (45%), agency publications (45%) and tape (17%). On the other hand, the use of floppy disks (8%), on-line data service (5%) and CD-ROM (1%) are indeed at disappointingly low levels. Despite tremendous benefits which can be gained by using microcomputer technology for data access and analysis, the agricultural economics profession has been extremely slow to capitalize on these benefits. Lags in the adaptation to modern technology lead to the **technological obsolescence of our data systems.** A severe consequence is the **under-utilization of our valuable resources -- data and the computer.** Effective utilization of new information technology to enhance the efficiency and effectiveness of our database systems is among the more pressing data issues for the 1990's.

With the advent of the third technological frontier, dramatic changes in the conceptual and operational meanings of our database systems can be anticipated. Information technologies will likely facilitate the whole institutional change process and the development of technological infrastructure. Much has been written concerning technology-induced social economic changes. Whether it is "technological push" or "market pull," or as a factor of production or a shift of production frontier, institutional changes primarily should increase competition, decrease costs, improve efficiency and add to the responsibilities of agricultural analysts (McGrann).

Successful adoption of information technologies builds the technological infrastructure, allowing end user applications to proceed smoothly and efficiently. This technological infrastructure generally consists of the key functional elements of support, control, education and communication. With further expansion of advanced information technologies, there are pressures to upgrade the technological infrastructure to satisfy the needs of more complex applications that lie outside the traditional domain of low-level requirements. The challenges for agricultural economists will be twofold: to develop high-level and complex application systems while simultaneously upgrading its infrastructure to meet with the requirements of a new technological frontier.

The fundamental driving forces contributing to the success of the end user computing revolution are integration and standardization. In the areas of engineering and manufacturing applications, integration and standardization are the most critical success factors. Computer Integrated Manufacturing (CIM) has been widely adapted to meet with integrated information processing requirements for the technical and operational tasks of an industrial enterprise. Achievement of this level of integration requires interfaces at the organizational level and a coordination of hardware and software development for the purpose (Scheer). Obviously, system integration for end user computing should also be considered as a strategic planning problem rather than a technical and operational application. In planning systems integration, it is important to develop agricultural applications from strategical, technical and operational considerations.

DATA AND INFORMATION SYSTEMS INTEGRATION

One of the greatest needs in the design and implementation of agricultural databases is the establishment of the end user computing objective. A data system must be considered an integral part of the design of an overall information system, satisfying the ultimate purpose of information management. In a symposium at the 1987 AAEA annual meetings, Bonnen expressed concerns regarding overemphasis on technique over data and a flight from empirical attitude. Perhaps a fundamental remedy is to stress the importance of an integrated data and information system incorporating analytical techniques, brought together by computer technology for real-time and real-world problem-solving applications.

A top priority in implementing an information strategy in agriculture is to emphasize such data and information systems integration. A good example is the computerized information/decision support systems, the CIDSS. Development of such a system raises questions on its information design, economic justifications, functional support as well as policy impacts (McCarl). A wide range of decision support systems are currently available in supporting decision-making by public and private institutions. Selected for discussions in this paper is a structural econometric model of a farm commodity sector. A simple diagram is used to illustrate such an on-line and ongoing data and decision support systems in the Figure 2. The diagram shows a knowledge-based decision making process, with the key decision-support activities of forecasting, simulation and control, two illustrative examples of EUC application systems, and an integrated database to be linked with each system component. The overall structure is based on the integrated database system designed for manufacturing industry, the well-known case of CIM (Scheer).

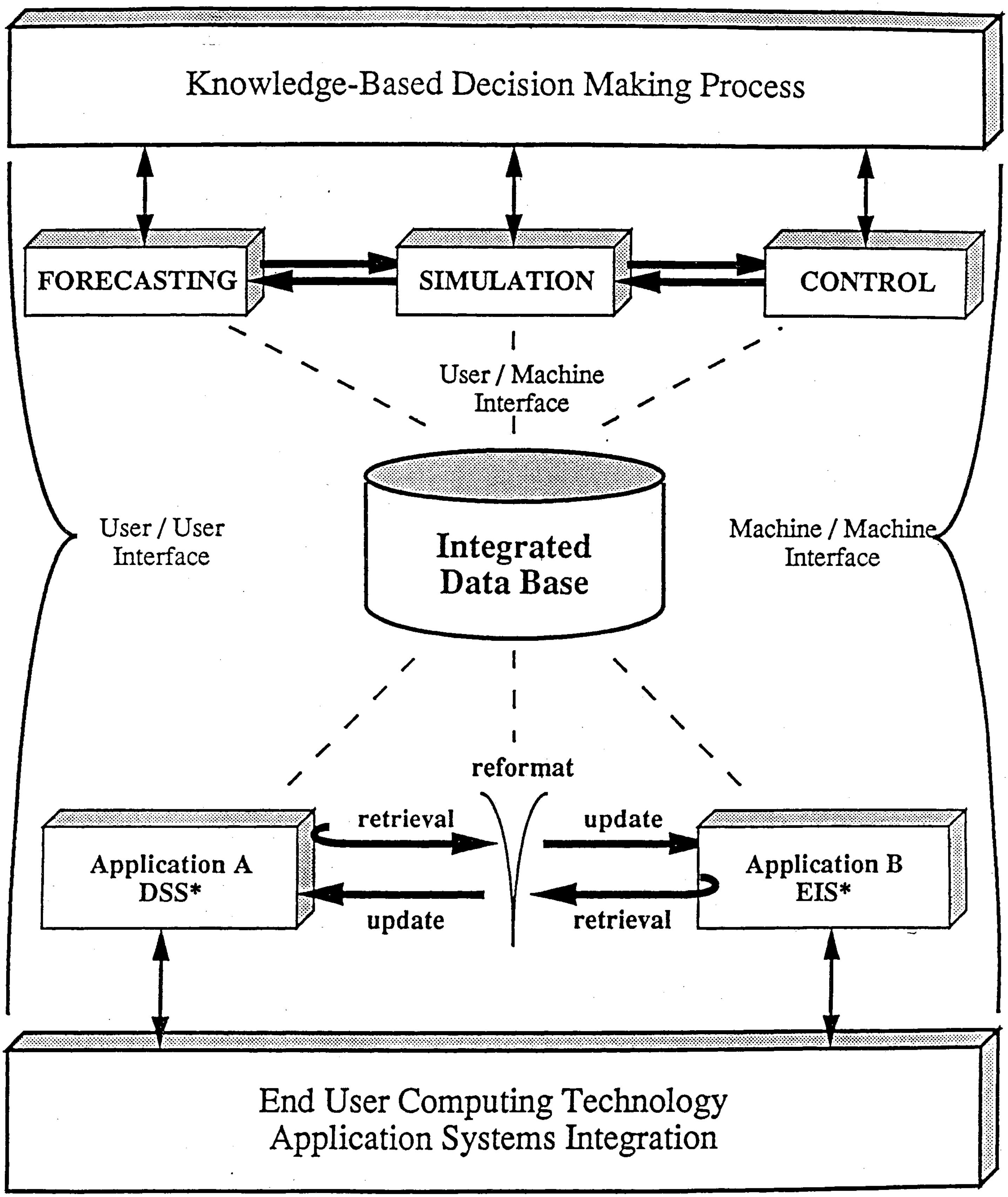
An important feature of this design is the integration of two application systems of DSS (Decision Support System) and EIS (Executive Information System), showing the linkages with the integrated database. Shown at the center of the diagram is an application-independent database organization -- the database structure and format, independent of any single application, allows interfacing of all applications in the overall system.

In addition to data integration, as achieved through an application-independent data organization, there are linkage mechanisms to provide feedback loops between application systems and the integrated database. Each application system provides the capability of data retrieval, data update, and data reformat in order to develop process chains. In this system, processes are considered in terms of their interactions, independent of the central database and supported by a closed information system.

A simple representation of the knowledge-based decision making process shows the decision-making activities of forecasting, simulation and control. As an on-line and ongoing system, system integration is achieved through activities and solutions of each application system.

Among many conditions that influence the operation of this integrated data and information

Figure 2: **Data and Information Systems Integration**



* DSS = Decision Support System, EIS = Executive Information System

system, the most critical factors are the three types of interfaces:

User/Machine Interface

User/User Interface

Machine/Machine Interface

Developmental work in earlier years was concentrated on the user/machine interface. More recently, focus has been on the machine/machine interface. Innovation and the adoption of hardware and software technologies had contributed to substantial improvement in each area. The strong push towards the networking of computers exists on many levels of integration (e.g., personal computer local area networks (LANs), pc/mainframe, pc/workstation, workstation/workstation, workstation/mainframe). However, the focus for the future involves the end user computing technology and the relationship between user and user. This interface is actually built on the relationships of user/machine and machine/machine, where these interfaces have been developed to reach the ultimate goal of interface between users. Given these enhanced interrelationships, one can see a tremendous potential for improved modeling operation in the future (Fuller).

AN INTEGRATED ECONOMETRIC MODELING SYSTEM

As an illustrative example for presentation is a large-scale structural econometric model of the U.S. farm commodity sectors developed and maintained by farm commodity sector at the Texas A&M University. This is an integrated data and econometric modeling system with five major components:

(1) Database Management,

(2) Command Datafile,

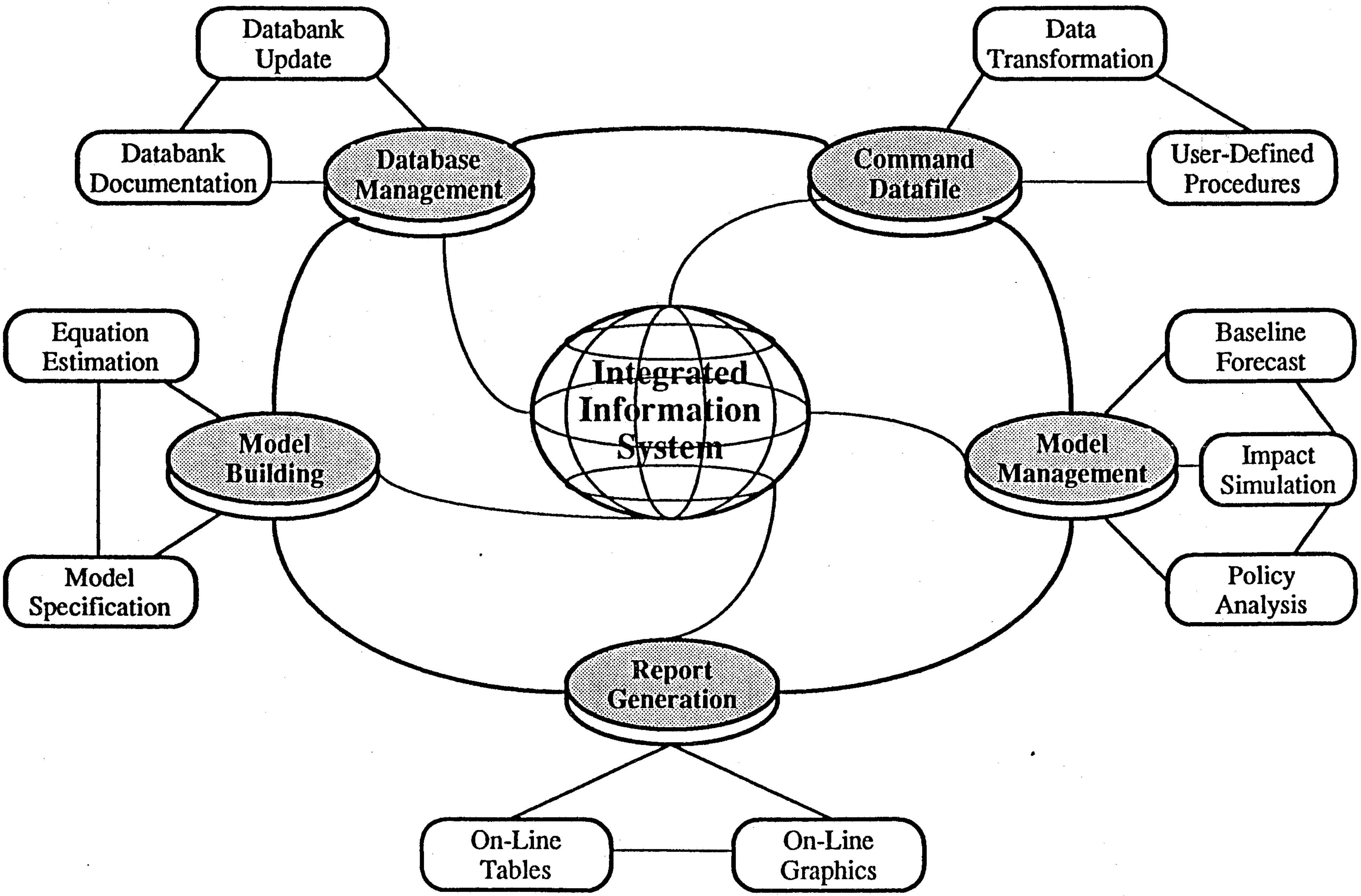
(3) Model Building,

(4) Model Management, and

(5) Report Generation.

The importance of integration of this system can be shown through examination of each component and of the interdependencies between them. The database management system in support of the overall information system consists of the databank and the command datafile. Databanks

Figure 3: **An Agricultural Econometric Modeling System**



provide the base from which data information is managed and utilized effectively. Command datafiles provide the mechanisms by which the database is managed by a series of commands that will access or build the information stored in the databanks.

In the example provided in Figure 4, there are two databanks, a monthly cotton databank (COT89M.BNK) and an annual cotton databank (COT89A.BNK). Command datafiles (CMD) exist for data transformation, data update, supply-utilization balance check, cross-frequency conversion and check, and data documentation.

Data transformation (TRAN) command files are used in three ways:

(1) transformation or formulation of existing time series to create new series,

(2) monthly to annual (MA) conversion of data, and

(3) annual to monthly (AM) conversion of data.

For the conversion of monthly to annual data (a higher to lower frequency) several methods of conversion are necessary. Based on the framework of stock and flow analysis, there are essentially two major types of data: (1) stock data - the data at one point of time, and (2) flow data - data covering a period of time. Command file MAHT, converts monthly stock data (HT) to annual crop year stock data; MAMA converts monthly average (MA) to annual crop year average; MAMT converts monthly total (MT) to annual crop year total. Similar command files carry out the annual to monthly conversions.

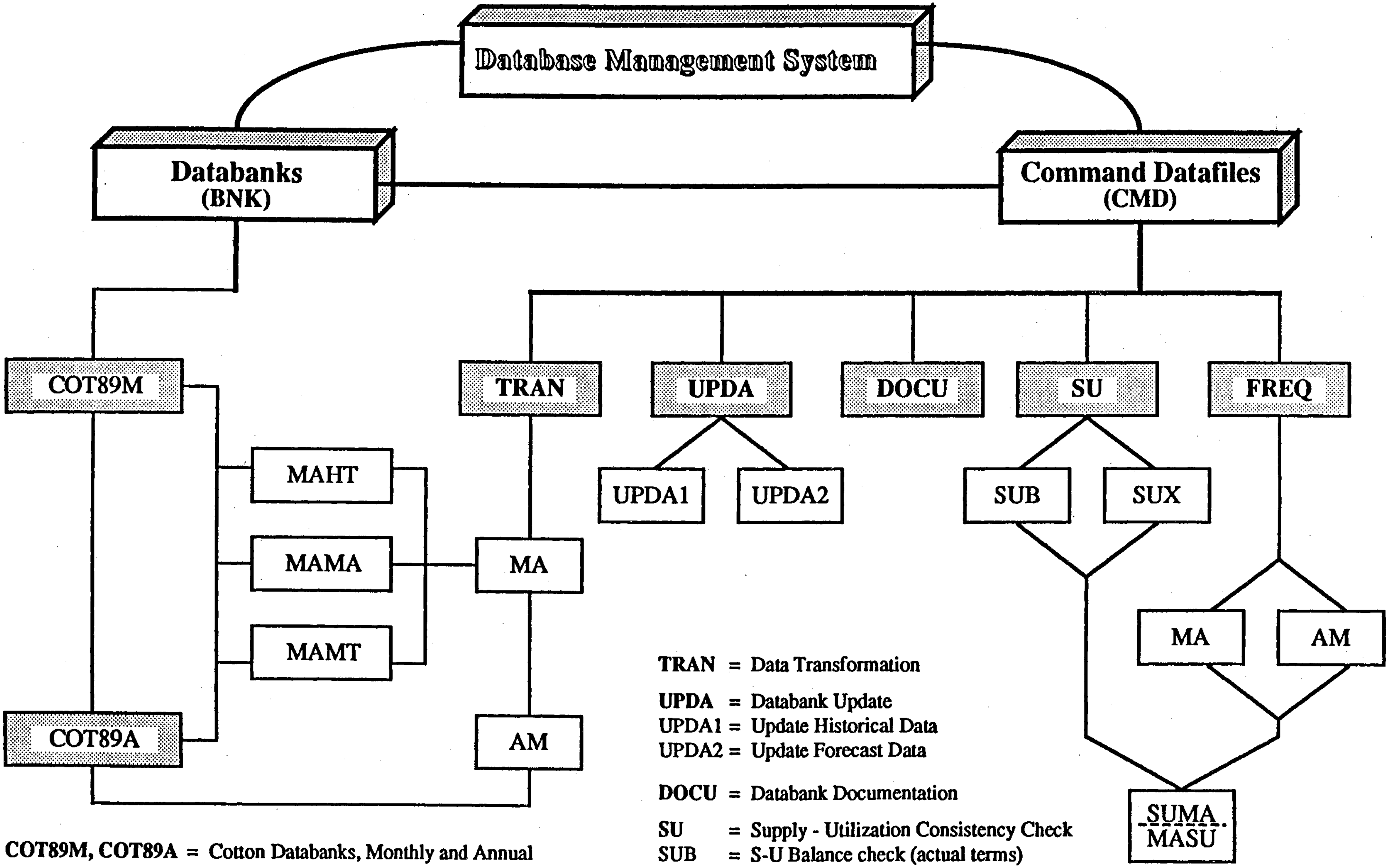
The update of databanks (UPDA) is performed with two types of command files. The first type (UPDA1) is the update of historical data, and the second type (UPDA2) involves data revisions and forecast data based upon exogenous variables and initial values of endogenous variables.

As the examination of the information system progresses, it is important to realize that database management and command datafiles are not one-dimensional data tools. These components are the foundation of the information system, and only through their interaction with each and all component, can we achieve a complete modeling system.

As one aspect of the interdependencies, the consistency and validity of the database system are essential to model building and management. The command file SU accomplishes a supply-utilization balance check. The supply-utilization balance in actual terms is verified in SUB, while

Figure 4: **Database Management System for an Econometric Model**

(AGGIES / Cotton)



TRAN = Data Transformation

UPDA = Databank Update
UPDA1 = Update Historical Data
UPDA2 = Update Forecast Data

DOCU = Databank Documentation

SU = Supply - Utilization Consistency Check
SUB = S-U Balance check (actual terms)
SUX = S-U Balance check (expectation terms)

FREQ = Multi - Frequency Data Consistency Check
SUMA = Combined S-U and MA check
MASU = Combined MA and S-U check

COT89M, COT89A = Cotton Databanks, Monthly and Annual

MAHT, MAMA, MAMT
= Monthly to Annual conversions of Stocks, Moving Average, and Total

MA = Monthly to Annual conversion
AM = Annual to Monthly conversion

a check in expectation terms is performed in SUX. The command file FREQ uses the methods of monthly to annual and annual to monthly conversion as a check for consistency between frequencies of data. The combined AM and MA check is used in conjunction with a combined SU check (SUB and SUX). The result of these combined checks is either a combined SU and MA check, SUMA (SU takes priority), or vice versa, MASU.

The model building process involves two major steps: (1) specification of the model, and (2) estimation of the equations. This process is important in reaching a higher level of abstraction, i.e., the level of the model. Because of the needs for timely update and modification of the model, the ability to refine and re-specify the model is an important iterative process. The extension to this process is managing the model to answer "What if?" questions and for impact simulation and policy analysis.

The concept of interdependency is also applied to model building and management to affect report generation and writing. The ultimate goal of this modeling system is to provide fast, accurate, comprehensive and consistent sets of information for dissemination and communication to clientele. For this reason, this is a multifrequency model with flexible size and sequential solution capability.

<u>Multi-Frequency, Flexible-Size and Sequential Solution</u>

I. Multi-Frequency Operation (Arithmetic Operation)

$Y_{i,j,t}$	->	$Y_{j,t}$	->	Y_t
Highest Frequency (Monthly)		Intermediate Frequency (Quarterly)		Lowest Frequency (Annual)

II. Flexible-Size Operation (EX-EN Operation)

$$X_{u,v,k} = \begin{cases} X_u, & u = 1,\ldots U \quad \text{(Commodity Disaggregation)} \\ X_v, & v = 1,\ldots V \quad \text{(Functional Disaggregation)} \\ X_k, & k = 1,\ldots K \quad \text{(Sectoral Disaggregation)} \end{cases}$$

III. Sequential Solution Operation (SO-DE Operation)

$$Z_{m,n} = \begin{cases} Z_m, & m = 1,\ldots M \quad \text{(Workstation Delivery Module)} \\ Z_n, & n = 1,\ldots N \quad \text{(Microcomputer Solution Module)} \end{cases}$$

The model selected for illustration is an integrated data and information system for world cotton fiber and textiles. This is a decision support system designed for monitoring global market information, projecting industry trends, evaluating weather and market uncertainties, examining structure and performance characteristics of international (cotton-fiber/textiles) market linkages, and for assessing policy impacts of new farm legislation and trade liberalization. No fully integrated systems for the cotton market and associated industries currently exist, and this cotton model is currently under substantial expansion in the world cotton and fiber markets. Considerable experience has been gained over time by testing and using this data and modeling system for forecast and impact simulation of the U.S. cotton market. A fully integrated system will be developed to incorporate global databases and advanced modeling technology. The package is designed for end users who are working with data applications or doing retrieval aspects of decision support applications. A major step forward is to develop two end user subsystems: a market decision system for price forecasts and risk analysis, and a policy simulation system for farm program analysis and evaluation of the effects of trade liberalization. The system is expected to be used for ongoing market price forecasts, risk analysis and interactive policy analysis.

CONCLUDING REMARKS

It is becoming increasingly apparent that information technology is one of the most significant forces affecting agriculture and rural areas in the coming decade. After a brief review of the technological frontier I believe dramatic changes are on the way to provides a new environment for data creation, dissemination and utilization.

In light of the rapid technological advancement, costs of data are expected to drop, while rates of returns on data investments should rise. A serious problem for us is the underutilization of data and database systems. It is generally agreed that an important reason is the lack of recognition and professional reward regarding data work and practical empirical work in response to real world problems.

There are tremendous opportunities available for agricultural economists to enhance our database and provide practical problem-solving research in a university environment due to the advancement of information technologies and the increasing complexity of modeling requirements.

To meet these challenges, we need to move aggressively with the following research activities:

■ Data base development must begin with systems design with due attention to the analytical needs of accuracy, timeliness, consistency, comprehensiveness, and on-line and interactive capabilities.

■ Design and implement integrated database and information systems for real-time and real-world applications in supporting decision making for the public and private sectors.

■ Develop technological infrastructures to enhance information system development and application.

■ Enhance efficiency and effectiveness in the overall process of data creation, dissemination and utilization. While we have been striving to preserve, substitute and create data resources, we seem to have underutilized our data resources.

A state-of-the-art assessment of database and information systems by government, industry and university representatives seems to provide useful information on the nation's data systems. Frequent update of this state-of-the-art assessment should be valuable guidance to developing data policy for agriculture and rural areas.

We need to stress the importance of quality of data and systems integration for real-world problem solving purposes. Gearing up to produce integrated knowledge products rather than individual parts will require some new organizational alignments in research (Rawlins). A systems approach will be essential in the design and implementation of our data systems in the face of changing research needs of the 1990's.

REFERENCES

AAEA Committee on Economic Statistics. "Our Obsolete Data Systems: New Directions and Opportunities" *Amer. J. Agr. Econ.* 54:5, December 1972, pp. 867-880.

Betz, Federick. *Managing Technology.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1987, pp. 48-69.

Bonnen, James T. "Improving the Socioeconomic Data Base." In *Agriculture and Rural Areas Approaching the Twenty-first Century*, ed. by Hildreth, R.J., K. L. Lipton, K. C. Clayton and C. C. O'Connor, Ames, IA: Iowa State University Press, 1988, pp. 452-489.

_________. "The Status of Agricultural Data Systems as the Basis for Policy." Presented at the Organized Symposium, "Relevance of Agricultural Economics: Obsolete Data Concepts Revisited." AAEA Annual Meeting, Michigan State University, August 2-5, 1987.

_________. "Improving Information on Agriculture and Rural Life." *Amer. J. Agr. Econ.*, 57:5, December 1975, 57:5, pp. 753-763.

Castle, Emery N. and R. J. Hildreth. "An Overview: Agricultural Economics at Crossroads." In *Agriculture and Rural Areas Approaching the Twenty-first Century*, ed. by Hildreth, R.J., K. L. Lipton, K. C. Clayton and C. C. O'Connor, Ames, IA: Iowa State University Press, 1988, pp. 452-489.

Cotterell, Arthur, ed. *Advanced Information Technology in the New Industrial Society.* The Kingston Seminars. New York: Oxford University Press, 1988.

Dahlgran, Roger A., "Agricultural Economists in the Information Age: Awareness, Usage, and Attitudes toward Electronic Bibliographic Databases." *Amer. J. Agr. Econ.* 69:1, February 1987, pp. 166-173.

Fuller, Earl I. "Microcomputers: Useful in All of Agricultural Economics and Extension." *Amer. J. Agr. Econ.* 64:5, December 1982, pp. 978-985.

Gardner, Bruce. "Fact and Fiction in the Public Data Budget Crunch." *Amer. J. Agr. Econ.* 65:5, December 1983, pp. 882-888.

Hollingum, Jack. *Implementing An Information Strategy in Manufacture: A Practical Approach.* IFS (Publications) Ltd. UK. Berlin: Springer Verlag, 1987, pp. 61-69.

Hushak, Leroy, Wen Chern and Luther Tweeten. "Reports of Survey Results." Pre-Meeting Workshop on New Directions in Data, Information Systems, and Their Uses, LSU, Baton Rouge, LA., July 28-29, 1989.

Just, Richard E. "The Impact of Less Data on the Agricultural Economy and Society." *Amer. J. Agr. Econ.* 65:5, December 1983, pp. 872-881.

Knutson, Ronald D. "Current and Future Agricultural Statistics: Adjusting to a Changing Clientele." Paper presented at NASS Planning Conference, Houston, Texas, 1987.

Litzenberg, Kerry K. "Computer Use in the Agricultural Economics Classroom." *Amer. J. Agr. Econ.* 64:5, December 1982, pp. 970-977.

McCarl, Bruce A. "Decision Support Systems in Agriculture." *WCC Journal of Computer Applications* Vol. 1, Number 1 1986, pp. 7-12.

_________. "Computers and Agricultural Economics Research." In *Computer Use by/and Computer Interface Among Agricultural Economics Institutions.* Carl O'Connor and Russell Gum, eds. Special Report 759, Agricultural Experiment Station and Extension Service, Oregon State University, Corvallis, OR, January 1986, pp. 1-21.

McGrann, James M. "How Will Information Technologies Facilitate the Changing Role of Extension." Paper presented at Agricultural Extension Service, Montana State University, Bozeman, Montana, Department of Agricultural Economics, Texas A&M University, College Station, TX, November, 1988.

Panko, Raymond R. *End User Computing: Management, Applications and Technology.* New York: John Wiley & Sons, 1988, pp. 1-48 and 655-702.

Putler, Daniel and David Zilberman. "Computer Use in Agriculture: Evidence from Tulare County, California." *Amer. J. Agri. Econ.* 70:4, November 1988, pp. 790-802.

Rawlins, Stephen L. "System Science: Organizing Research to Deliver Integrated Products." Presentation as part of theme session, "Systems Research: Putting the Pieces Together." Texas A&M Agricultural Experiment Station annual staff conference, College Station, Texas, January 13, 1988.

Scheer, A.W. *CIM: Computer Integrated Manufacturing.* Berlin: Springer-Verlag 1988, pp. 3-15.

Schertz, Lyle. "Toward Consensus in Adopting Improved Data Concepts." Presented at The Organized Symposium, "Relevance of Agricultural Economics: Obsolete Data Concepts Revisited." AAEA Annual Meeting, Michigan State University, August 2-5, 1987.

Stanton, B. E. "The Quest for Improved Agricultural Data: Concepts and Measurement." The Organized Symposium, "Relevance of Agricultural Economics: Obsolete Data Concepts Revisited." AAEA Annual Meeting, Michigan State University, August 2-5, 1987, pp. 1-5.