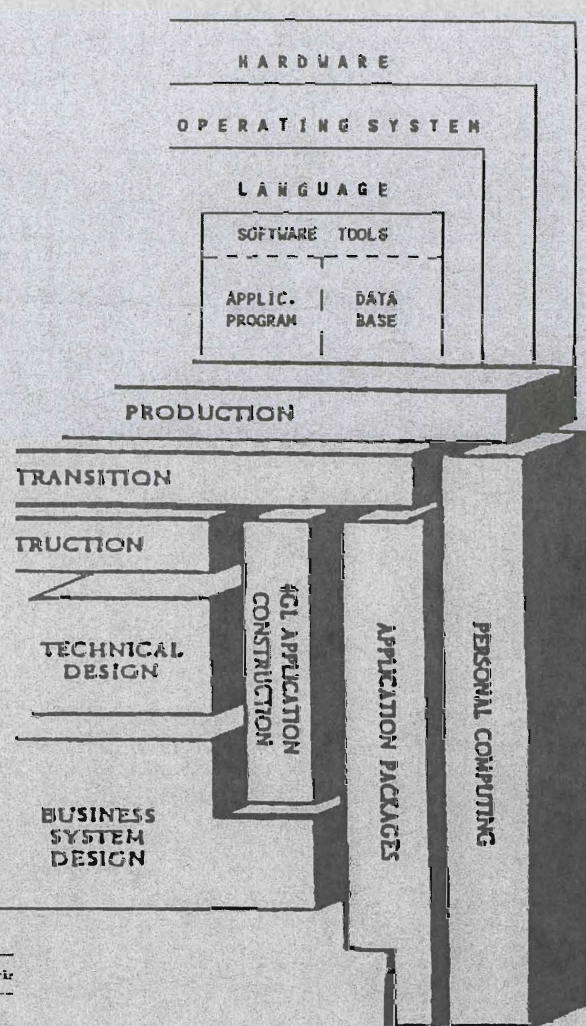
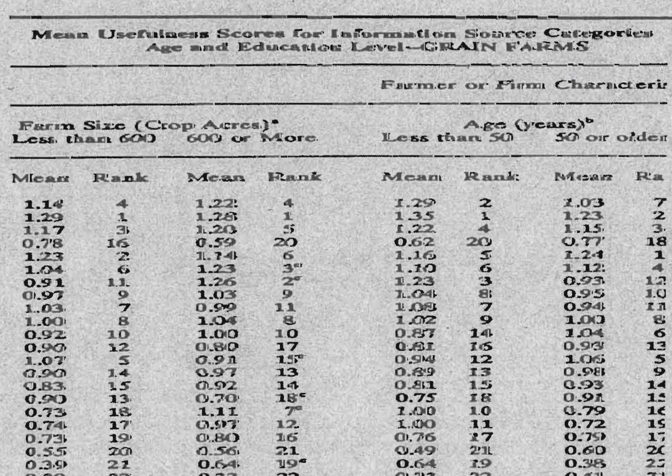
Future Directions for Farm Information Systems Research

Proceedings of a program sponsored by the NC–191 Committee on Farm Information Systems

Minneapolis, Minnesota
May 1–3, 1989





Mean Usefulness Scores for Information Source Categories
Age and Education Level—GRAIN FARMS

Farmer or Firm Characteri							
Farm Size (Crop Acres)[a] Less than 600		600 or More		Age (years)[b] Less than 50		50 or older	
Mean	Rank	Mean	Rank	Mean	Rank	Mean	Ra
1.14	4	1.22	4	1.29	2	1.03	7
1.29	1	1.28	1	1.35	1	1.23	2
1.17	3	1.20	5	1.22	4	1.15	3
0.78	16	0.59	20	0.62	20	0.77	18
1.23	2	1.14	6	1.16	5	1.24	1
1.04	6	1.23	3[c]	1.10	6	1.12	4
0.91	11	1.26	2[c]	1.23	3	0.93	12
0.97	9	1.03	9	1.04	8	0.95	10
1.03	7	0.99	11	1.08	7	0.94	11
1.00	8	1.04	8	1.02	9	1.00	8
0.92	10	1.00	10	0.87	14	1.04	6
0.90	12	0.80	17	0.81	16	0.93	13
1.07	5	0.91	15[c]	0.94	12	1.06	5
0.90	14	0.97	13	0.89	13	0.98	9
0.83	15	0.92	14	0.81	15	0.93	14
0.90	13	0.70	18[c]	0.75	18	0.91	15
0.73	18	1.11	7[c]	1.00	10	0.79	16
0.74	17	0.97	12	1.00	11	0.72	19
0.73	19	0.80	16	0.76	17	0.79	17
0.55	20	0.56	21	0.49	21	0.60	20
0.39	21	0.64	19[c]	0.64	19	0.38	22
0.39	22	0.33	22	0.33	22	0.41	21

Information–ALL FARMS

Marketing %	Marketing Rank	Production %	Production Rank
10.22	4	13.44	3
11.45	2	13.77	2
5.11	7	5.74	7
0.82	19	2.46	11
16.36	1	2.79	10
4.91	8	12.95	4
10.84	3	3.61	8
4.09	10	7.21	6

Miscellaneous Publication 65–1990
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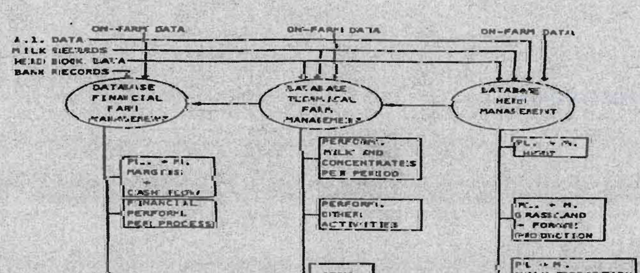

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Edited by
Robert P. King

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St. Paul, Minnesota

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FUTURE DIRECTIONS FOR FARM INFORMATION SYSTEMS RESEARCH

Contents

PREFACE

The papers in this proceedings were presented at the 1989 meeting of the North Central Regional Research Project NC-191, Farm Information Systems. This was the first meeting of a five-year research effort with two major objectives:

- To analyze the need for, value of, and factors affecting the adoption of farm information systems.

- To design and evaluate data base structures and modeling strategies for building farm information systems.

Cooperating states in the project are: Illinois, Indiana, Iowa, Michigan, Minnesota, New York, North Carolina, North Dakota, Ohio, and Wisconsin. The project's administrative advisor is Dr. Donald Field, Associate Dean of the School of Natural Resources at the University of Wisconsin.

We gratefully acknowledge the Farm Foundation for the financial support they provided for the travel expenses of Vinus Zachariasse. Special thanks also go to Mary Adelman of the University of Minnesota, who coordinated the technical aspects of preparing this publication.

Robert P. King
University of Minnesota
February 1990

SOURCES AND USES OF FARM MANAGEMENT INFORMATION: FINDINGS FROM THE OHIO STATE UNIVERSITY SURVEY

Marvin T. Batte, Gary D. Schnitkey, and Eugene Jones*

Introduction

Farmers do not operate in a static environment. Production technologies and practices are continually changing; input and output prices vary considerably within short time periods; government policies dealing directly and indirectly with agriculture are in a constant state of flux; and world financial and agricultural markets are in continual adjustment. Within this environment, reliable information will aid farmers in decision making by altering or confirming managers' views of possible outcomes.

During the past decade, information options available to farmers changed substantially. Developments in computer and telecommunication technologies have increased the potential for improved measurement, processing, and timely dissemination of information. Although information technologies expanded greatly during the past decade, our understanding of farmers' use of information has not expanded greatly. Theoretical studies suggest that information can play a key role in decision making (Taylor and Chavas; Chavas and Pope). Moreover, researchers have hypothesized that information use will be influenced by farm organization, farm size, farmer innovativeness, and the ability to use information (Sonka). While this may be true, empirical studies have not been conducted to confirm or refute these hypotheses.

This paper examines farmers' use of information and how information use varies with differing farm and farmer characteristics and across decision types. Results will contribute to a better understanding of information's role in decision making, provide insights into types of information farmers desire, and provide insights into the attributes of information sources that farmers prefer. These results should help guide the development of further research as project NC-191 gets underway.

Data Source and Methodology

Farmers' information use was studied using data from an 11-page, mailed survey. The survey included questions eliciting (1) farmers' perceptions of information adequacy and information source usefulness; (2) farmers' uses of computers, satellite dishes, and accounting systems; (3) basic farm characteristics such as farm size, enterprises, and business organization, (4) farmers' use of various production and marketing practices, and (5) basic

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characteristics of the farmer such as age and education level. The survey was mailed to 1,800 Ohio commercial farmers using the Dillman repeat method of surveying. Fifty-three percent of the questionnaires were returned. Of these, 730 farmers were farming and completed the instrument. An additional 227 returned incomplete surveys. These were largely retired farmers or others who had exited farming. A small number refused to answer the survey. Descriptive statistics for the sample are reported in Table 1.

Responses were categorized into farm types based upon the predominant farm enterprise. Grain farms--those with at least 200 crop acres and without significant livestock enterprises--comprised nearly 40 percent of the respondents. Dairy farms--farms with at least 20 dairy cows and no other significant livestock enterprises--accounted for almost 31 percent of the respondents. The remaining 30 percent were classified as mixed livestock farms. These farms did not have dairy cows but did have at least one other significant livestock enterprise.

Current Information Sources

The mailed questionnaire contained a number of questions designed to elicit the sources of information used in farm decision making. Twenty-three information sources were identified, ranging from very informal sources (e.g., personal communications with other farmers, salesmen, and lenders) to highly formalized sources including marketing consultants, computerized information services, and accountants.

Reported in Table 2 are the information source categories, the percentage of farmers utilizing each of these information sources, and a summary of farmers' evaluations of the usefulness of each source. General farm magazines are the most commonly received source category--97 percent indicated subscription to such periodicals. This source was followed by the use of radio reports, communication with other farmers, and local newspaper subscriptions--all with over 93 percent of the farmers reporting usage. Information sources most infrequently received are computerized information sources, veterinarians, brokerage firms, marketing consultants, and national newspapers.

Farmers were asked to rank the usefulness of each information source as either VERY USEFUL, USEFUL, NOT USEFUL, or DO NOT RECEIVE. Based on the usefulness rankings, a mean usefulness score was developed. Responses of VERY USEFUL, USEFUL, and NOT USEFUL were assigned weights of 2, 1, and 0, respectively.[1] These weights are simply an ordinal ranking intended to assign relative values. An information source with a weight of 2 is not to be interpreted as being twice as valuable as an information source with a weight of 1. The weighted responses were then averaged, excluding those who responded that they "DO NOT RECEIVE" the information. Excluding DO NOT RECEIVE responses implies that these farmers are not in a position to judge the usefulness of the information source. Although this implication may not be strictly true--farmers may not use a particular information source because it costs more to obtain than it is worth--including DO NOT RECEIVE responses would presume more than we currently know.

Table 1. Descriptive Statistics for Selected Farm and Farmer Characteristics, Ohio Commercial Farms, 1987

Measure	Percent
Operator:	
Age	
Less than 35	16.8
35 - 44	21.7
45 - 54	25.3
55 - 64	23.4
65 and older	12.7
Education	
Grade school	4.8
High school	71.1
College	19.5
Post-graduate	3.6
Working off the farm	29.1
Farm Type:	
Dairy	30.6
Grain	39.5
Mixed	29.9
Dairy Farm Size (cows):	
20-39 cows	27.9
40-59 cows	32.3
60-79 cows	22.3
80 or more cows	17.5
Grain Farm Size (crop acres):	
200 - 399	40.5
400 - 599	23.8
600 - 799	14.8
800 and more	20.9
Respondent's Role in the Business:	
Sole owner	58.9
Equal participant	15.4
Senior participant	17.7
Junior participant	5.0
Other	2.9
Business Plans:	
Expand farm size	25.4
Maintain constant size	60.4
Reduce farm size	5.2
Retire or exit farming	8.9

Table 2. Mean Usefulness Scores for Various Information Source Categories

Information Source	Percent Receiving				Mean Usefulness Score			
	All	Dairy	Grain	Other	All	Dairy	Grain	Other
N	691	159	227	301	691	159	227	301
Specialized farm magazines	76.12	88.67	63.87	78.40	1.412	1.709	1.179	1.368
General farm magazines	95.80	93.71	96.91	96.01	1.309	1.416	1.286	1.262
Agricultural newspapers	82.92	83.64	80.17	84.38	1.254	1.300	1.181	1.283
Veterinarian	72.35	90.56	37.88	88.70	1.186	1.493	0.674	1.179
Radio reports	92.61	89.30	94.71	92.69	1.162	1.056	1.190	1.193
Cooperative Extension Service	90.01	91.82	88.10	90.36	1.146	1.308	1.115	1.088
Commercial newsletters	53.69	40.25	56.38	58.47	1.037	0.875	1.070	1.062
Other farmers	92.76	89.30	93.83	93.68	1.026	1.133	0.990	1.000
Salesmen	90.73	89.30	88.10	93.35	1.003	1.042	1.025	0.971
USDA and government publications	87.12	88.05	85.46	87.70	0.958	0.935	1.005	0.935
Accountant	67.72	67.92	67.40	68.10	0.942	0.916	0.967	0.936
Tax preparer	78.87	79.87	78.85	78.07	0.941	1.007	0.877	0.948
Television reports	86.54	78.61	90.74	87.37	0.921	0.792	1.009	0.916
Crop Reporting Service reports	82.48	79.24	83.25	83.72	0.891	0.904	0.936	0.853
National newspapers	41.24	26.41	44.49	43.85	0.856	0.723	0.871	0.896
Local newspapers	92.32	90.56	93.39	92.35	0.829	0.798	0.816	0.856
Marketing consultant service	39.67	33.96	40.96	40.19	0.796	0.481	0.870	0.867
Computerized information services	31.69	28.93	30.83	33.88	0.751	0.543	0.871	0.764
Lender	73.80	73.84	74.44	73.42	0.749	0.743	0.763	0.733
Attorney	65.99	64.77	66.51	66.11	0.532	0.543	0.529	0.527
Brokerage firm	37.62	31.44	40.96	38.20	0.453	0.280	0.494	0.486
Insurance agent	77.27	80.50	76.65	75.74	0.393	0.437	0.356	0.390

Information sources ranking most highly are general farm magazines, radio broadcasts, agricultural newspapers, and specialized farm magazines (Table 2). Various responses to the survey indicate that managers are very concerned with the quality of information for marketing decisions.[2] However, most sources in the above list are general in focus. That is, they tend to provide information broadly addressing the enterprise, the business, or the agricultural sector. Thus, they may provide information for a number of business activities (marketing, financing, and production).

Information source categories earning the least favorable evaluations are insurance agents, brokerage firms, attorneys, veterinarians, and lenders (Table 2). There are a number of factors that may influence the usefulness of information from these sources. The context of the decision and, in particular, the economic importance of the decision is expected to be very influential. Because these farmers were selected to have no major livestock enterprises, veterinary information is not likely to be as important to these firms as is information relating to the grain enterprise. Attorneys provide information for decisions that are made infrequently (e.g., business organization decisions, construction of wills, etc.). Even though these decisions may be of great economic importance, they may be perceived by many to be of lower importance than other farm decisions. Furthermore, farm managers may not perceive these to be imminent decisions. That is, these decisions can be delayed. Finally, information from lenders, brokerage firms, or insurance agents may be perceived to be biased. These parties often have vested interests in the decisions made. Even though the information derived from these sources has value, it may be discounted relative to other sources perceived to be more accurate.

There are differences in the usefulness evaluations for different subgroups within the sample. Reported in Table 3 are mean usefulness scores for farmers grouped by farm size, age and level of formal education. These characteristics of the manager are hypothesized to influence their choice of information sources and their ability to glean from each source information useful for business management.

A t-test was employed to test the hypothesis of equal evaluation means for sample subgroups. When classified by farm size, mean usefulness scores are significantly different for six information source categories. Larger farms give significantly higher evaluation scores for the Cooperative Extension Service (CES), commercial newsletters, marketing consultants and information from brokerage firms than do small farms. They give significantly lower evaluations for television reports and local newspapers. These results may be explained largely by differences in the rigor of information requirements. Survey results indicate that larger farms tend to use more complex marketing methods. Larger farms employ substantially more forward contracting than do smaller farmers. Similarly, they more frequently use hedging techniques (both futures and options markets), are more likely to store their crop for sale after harvest, and more frequently participate in "PIK and Roll" strategies. Hence, they have greater need for specialized information sources.

Farmers more than 50 years of age gave significantly higher evaluation scores for the local newspapers, but significantly lower scores for specialized farm magazines, commercial newsletters, and brokerage firms than did younger farmers. Respondents with college

Table 3. Mean Usefulness Scores for Information Source Categories By Farm Size, Age and Education Level--GRAIN FARMS

Information Source	Farmer or Firm Characteristics											
	Farm Size (Crop Acres)[a]				Age (years)[b]				Education			
	Less than 600		600 or More		Less than 50		50 or older		High School		College	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
Specialized farm magazines	1.14	4	1.22	4	1.29	2	1.03	7[c]	1.18	4	1.14	3
General farm magazines	1.29	1	1.28	1	1.35	1	1.23	2	1.30	1	1.26	1
Agricultural newspapers	1.17	3	1.20	5	1.22	4	1.15	3	1.20	3	1.10	4
Veterinarian	0.78	16	0.59	20	0.62	20	0.77	18	0.78	19	0.31	20[c]
Radio reports	1.23	2	1.14	6	1.16	5	1.24	1	1.25	2	0.97	9[c]
Cooperative Extension Service	1.04	6	1.23	3[c]	1.10	6	1.12	4	1.12	5	1.09	5
Commercial newsletters	0.91	11	1.26	2[c]	1.23	3	0.93	12[c]	1.06	8	1.17	2
Other farmers	0.97	9	1.03	9	1.04	8	0.95	10	1.06	7	0.70	15[c]
Salesmen	1.03	7	0.99	11	1.08	7	0.94	11	1.09	6	0.70	14[c]
USDA and government publications	1.00	8	1.04	8	1.02	9	1.00	8	1.01	11	1.00	7
Accountant	0.92	10	1.00	10	0.87	14	1.04	6	1.03	9	0.64	18[c]
Tax preparer	0.90	12	0.80	17	0.81	16	0.93	13	0.91	13	0.68	16
Television reports	1.07	5	0.91	15[c]	0.94	12	1.06	5	1.01	10	0.95	10
Crop Reporting Service reports	0.90	14	0.97	13	0.89	13	0.98	9	0.94	12	0.88	12
National newspapers	0.83	15	0.92	14	0.81	15	0.93	14	0.80	18	1.04	6[c]
Local newspapers	0.90	13	0.70	18[c]	0.75	18	0.91	15[c]	0.85	15	0.72	13
Marketing consultant service	0.73	18	1.11	7[c]	1.00	10	0.79	16	0.89	14	0.93	11
Computerized information services	0.74	17	0.97	12	1.00	11	0.72	19	0.82	16	1.00	8
Lender	0.73	19	0.80	16	0.76	17	0.79	17	0.80	17	0.63	19
Attorney	0.55	20	0.56	21	0.49	21	0.60	20	0.60	20	0.28	22[c]
Brokerage firm	0.39	21	0.64	19[c]	0.64	19	0.38	22[c]	0.46	21	0.68	17
Insurance agent	0.39	22	0.33	22	0.33	22	0.41	21	0.39	22	0.30	21

[a] Mean crop acreage is 604.4.
[b] Mean age is 48.8 years.
[c] Significant at the 10 percent probability level. A t-test of difference between means of the groups was employed.

degree work scored national newspapers significantly higher but scored radio broadcasts, accountants, attorneys, salesmen, veterinarians, and communications with other farmers lower than farmers with high school or elementary educations.

Also of interest from Table 3 is the consistently high evaluation scores given for general farm magazines, specialized farm magazines, radio broadcasts, the CES, and agricultural newspapers. Regardless of whether classified by age, size or education level, these sources rank in the top ten by usefulness score. Similarly, brokerage firms, insurance agents, attorneys, lenders, and veterinarians uniformly rank near the bottom. However, there are major differences in these rankings among groups. For instance, commercial newsletters rank third in usefulness for those farmers with the highest level of formal education, but thirteenth for the oldest group of farmers. Accountants rank seventh for the older group of farmer, but nineteenth for the most highly educated group. Computerized information sources rank ninth for the most highly educated and twentieth for the oldest and smallest farm producers.

Information Use for Specific Decision Needs

Three survey questions asked farmers to indicate the most useful information source for each of three decision areas: marketing, production, and financial decisions. Responses varied widely within each decision category as well as across the decision types (Table 4).

The three most frequently cited information sources for marketing decisions were radio broadcasts, general farm magazines, and commercial advisory newsletters. Radio broadcasts provide frequent market price updates for grain and livestock. This information probably supports the operational decision of price establishment. On the other hand, magazines and commercial advisory newsletters, because they are issued less frequently, address a longer decision timeframe. These probably still address marketing decisions relevant for the current production period, not longer run, strategic decisions.

Salesmen, general farm magazines, and specialized farm magazines were the three most commonly cited sources of production information (Table 4). Although salesmen are typically thought of as a potentially biased source of information because of their vested interest in the decision outcome, farmers none-the-less judge salesmen to be a highly useful source of production information. The CES ranked fourth with about 13 percent of all responses.

Lenders, accountants, and tax preparers were the three sources most frequently cited as most useful for financial decisions (Table 4). These three sources accounted for nearly 60 percent of all responses. Lenders are involved in evaluation and financing of capital investments and, thus, may be viewed as providing information for longer term decisions. Tax preparers and accountants primarily maintain transactions records and tax reports which address short run information needs; although, to the extent that they provide analysis and projection of firm profitability or tax liabilities, they may also provide information for investment (strategic) decisions.

Table 4. Most Useful Source of Marketing, Production, and Financial Information--ALL FARMS

Source	Marketing %	Marketing Rank	Production %	Production Rank	Financial %	Financial Rank
Specialized farm magazines	10.22	4	13.44	3	3.26	9
General farm magazines	11.45	2	13.77	2	4.80	4
Agricultural newspapers	5.11	7	5.74	7	2.23	12
Veterinarian	0.82	19	2.46	11	0.17	22
Radio reports	16.36	1	2.79	10	2.57	10
Cooperative Extension Service	4.91	8	12.95	4	3.60	8
Commercial newsletters	10.84	3	3.61	8	4.63	5
Other farmers	4.09	10	7.21	6	3.95	6
Salesmen	3.68	12	19.67	1	0.86	18
USDA and government publications	2.25	14	7.87	5	1.54	14
Accountant	1.02	18	0.49	18	14.75	2
Tax preparer	0.00	21	0.00	21	10.98	3
Television reports	4.50	9	1.48	14	0.86	19
Crop Reporting Service reports	1.64	16	2.95	9	1.20	16
National newspapers	3.27	13	0.49	16	3.60	7
Local newspapers	5.11	6	1.97	12	2.40	11
Marketing consultant service	7.77	5	1.64	13	1.72	13
Computerized information service	3.89	11	0.49	17	1.03	17
Lender	1.84	15	0.66	15	33.62	1
Attorney	0.00	22	0.00	22	1.54	15
Brokerage firm	1.23	17	0.33	19	0.34	21
Insurance agent	0.00	20	0.00	20	0.34	20

The Cooperative Extension Service as an Information Provider

The CES was ranked highly in all three decision categories. As a source of information for marketing and financing decisions, the CES was ranked as the most useful by approximately 5 percent of the respondents (Table 4). Over 13 percent of the respondents indicated that the CES was the most useful source of information for production decisions.

Recent decades have witnessed a substantial change in the structure of production agriculture. A bimodal farm size structure now exists. Similarly, part-time farming has become increasingly important; fewer farmers are full owners of farm real estate; and farm operators, on average, are older today than was true in the past. These changes have stimulated questions about the proper role of the CES. Some argue that the CES has promoted structural change by targeting its services to larger farm businesses. Others have questioned the future role of Extension, including whether its services will continue to be demanded by this changing group of farmers. Although information from the survey cannot be used to answer these very pointed questions, it may be used to understand how farmer satisfaction with CES information varies along structural lines.

A summary of farmer use of CES information by farm size (total acres), operator age, and operator education level is presented in Table 5. Age and education level are the most highly correlated with respondent identification of the CES as the most important information source for selected decisions. Older farmers tend to rank CES more highly than do their younger counterparts. Similarly, increased formal education is associated with a higher evaluation of CES as an information source. The influence of age and education is consistent across all three decision types.

Operator age and education are human capital indicators. Older farmers typically have more experience than younger farmers. Experience may impact on farmer information needs and/or preferences. Similarly, more educated farmers have a greater educational base to draw on when making decisions. By inference, these results suggest that farmers with more "human capital" tend to value more highly information provided by the CES.

Farm size influence is more varied. Respondents who operate larger farms more frequently cite CES as the most useful source of marketing information, but those with smaller farms give higher evaluations to CES for its role in support of production and financial decisions. Other evidence from the survey suggests that respondents with larger farms tend to have more complex marketing plans and use forward contracting and hedging more frequently than do respondents with smaller farms. Perhaps these differential marketing needs of respondents with larger farms are being addressed well through CES marketing and/or outlook programs and, thus, partially account for the higher evaluations.

Table 5. Percentage of Farmers Citing the Cooperative Extension Service As Their Most Important Source of Information for Marketing, Production or Financial Decisions

Source Category	Marketing	Production	Financial
All farmers	4.9	13.0	3.6
Farm size:			
less than 600 acres	4.3	13.5	3.8
600 acres or more	5.7	12.6	3.5
Operator age:			
less than 50	3.8	10.7	3.5
50 years and over	6.2	15.8	3.7
Education:			
high school or less	3.9	11.2	2.1
college	7.9	18.5	8.2

Table 6. Computer Use on Commercial Farms by Farm Size and Farm Type - Ohio, 1987

Item	All Farms	Grain	Dairy	Mixed Livestock
Number of farms	716	196	230	206
	------------	------------ percent	------------	------------
Ownership of Computers By:				
farms within each category	13.2	11.7	12.1	16.9[a]
grain farm size:				
600 acres or less	--	3.7	--	--
greater than 600 acres	--	21.3[b]	--	--
dairy farm size:				
60 cows or less	--	--	8.8	--
greater than 60 cows	--	--	18.0[b]	--
Uses of Computers By Farmers Using Computers:				
business accounting	61.6	80.6[a]	55.9	59.6
business planning	55.5	71.0	45.1	61.5
tax computation	39.7	45.2	35.3	42.3
business correspondence	15.0	22.6	9.8	15.4
production recordkeeping	58.9	41.9	82.3[a]	48.1
access to electronic information	19.2	25.8	13.7	19.2
Most Important Use of Computers:				
business accounting	35.6	45.2	29.4	38.5
business planning	23.3	25.8	11.8	36.5
tax computation	2.1	0.0	2.0	1.9
business correspondence	0.0	0.0	0.0	0.0
production recordkeeping	20.5	6.4	41.2[a]	7.6
access to electronic information	1.3	3.2	2.0	0.0

[a] Denotes significantly different from other farm types (5 percent test level).
[b] Denotes significantly different from other farm sizes (5 percent test level).

On-farm Computer Use

Computer use by farm business managers is reported in Table 6. Just more than 13 percent of all farmers reported use of computers. Differences exist in computer adoption and use among farm types and farm sizes. Significantly more mixed-livestock farmers reported computer use than did either dairy or grain farmers. Larger farms tend to have a higher incidence of computer ownership as indicated by the significant larger percentages for grain farms over 600 acres and dairy farms having over 60 cows. Also reported in Table 6 is a summary of uses of the computer within the business. Grain farms tend to use computers for accounting more than do dairy farms, while dairy farms tend to use computers more for production recordkeeping than do grain farms. With the exception of dairy producers, business accounting is most frequently cited as the "most important" application of the computer within the business. This is followed by business planning and production recordkeeping.

Factors Influencing Accounting System Selection

In this section, multivariate statistical techniques are used to address the question of "what farmer or firm characteristics influence the choice of accounting system?". The dependent variable in these analyses is the type of farm accounting system employed on the farm. Seven accounting systems were described in the survey. Farmers were asked to identify the system which best described their farm record system. Responses were placed into three categories: (1) no system--use of check stubs, bills, and receipts only, (2) manual systems--farm account book or manual single- or double-entry accounting techniques, and (3) computerized systems--computer-based or computerized mail-in record systems. Because the dependent variable is categorical, a qualitative choice model is required.

Three frequently used specifications for analyzing qualitative dependent variables are the linear probability model, the probit model and the logit model (Capps and Kramer; Pindyck and Rubinfeld). Pindyck and Rubinfeld argue that ordinary least squares (OLS) estimation of the linear probability model can provide estimates quite similar to the maximum likelihood estimation of the probit and logit models. However, estimates from the linear probability model are generally biased, inefficient, and inconsistent with a unit prediction range. Both the probit and logit models can be specified to overcome these statistical problems. Although there is little empirical basis for discriminating between the logit and probit models, the theoretical foundation of the logit model is more applicable to econometric theory (Capps and Kramer). Furthermore, the multinomial probit model involves probability expressions that are multiple integrals of the multivariate normal density (Aldrich and Nelson). Thus, the multinomial probit model is computationally impractical. The multinomial logit model, which is identified with the logistic distribution function, was used in these analyses. Maximum likelihood procedures are employed in the estimation.

The multinomial logit model was specified as follows:

$$\ln \frac{P_i}{P_j} = B_{0ij} + B_{1ij}\,SIZE + B_{2ij}\,AGE + B_{3ij}\,ED + B_{4ij}\,OWN + B_{5ij}\,PTIME + B_{6ij}\,TENANCY +$$

$$B_{7ij}\,FR + B_{8ij}\,MR + B_{9ij}\,ER + B_{10ij}\,DAIRY$$

Where

subscript i	=	ith class of the qualitative dependent variable
subscript j	=	jth class of the qualitative dependent variable
$\ln (P_i / P_j)$	=	natural logarithm of the probability of a class i relative to the probability of a class j
SIZE	=	total farm acreage
AGE	=	age measured in years
ED	=	education level (0 if high school or less, 1 if college)
OWN	=	number of owners (0 if single owner, 1 otherwise)
PTIME	=	off-farm work (0 if full-time farmer, 1 otherwise)
TENANCY	=	percentage of total land controlled by lease
FR	=	1 if balance sheets or income statements are prepared, 0 otherwise
MR	=	1 if enterprise or cash flow budgets are prepared, 0 otherwise)
ER	=	external records (1 if records are used for external reporting needs, 0 otherwise), and
DAIRY	=	dairy farm (0 if grain farm, 1 if dairy farm).

Only grain and dairy farms were included in the analysis. Estimated coefficients, asymptotic t-values, and marginal changes in probabilities for independent variables are reported in Table 7.

Size of the farm business was hypothesized to increase the complexity of the firm's accounting system. That is, more transactions need to be processed into reports. Estimated coefficients for SIZE are statistically significant for two of the three equations and their signs are consistent with the a priori hypothesis. Increased business size is associated with increased probability of a manual system relative to no accounting system (e.g., a system of only check stubs, bills, and receipts). It is also associated with increased probability of a computer accounting system relative to a manual accounting system.

Changes in probabilities are reported at the bottom of Table 7. Evaluations are made for one unit changes in the indicated variable with all other continuous variables held constant at their mean and with all other binary variables constant at zero. Thus, for a one acre increase in farm size (from its mean of 649 acres), holding all other variables constant, the probability of a manual computer system relative to no system increases by .00002. Similarly, the probability of having a computer-based accounting system relative to a manual system increases by .00004.

Table 7. Maximum Likelihood Estimates of Log Probabilities of Factors Associated with Accounting System Design

	log(P2/P1)[a]		log(P3/P1)[a]		log(P3/P2)[a]	
	B	t[b]	B	t[b]	B	t[b]
CONSTANT	-0.4026	-0.3815	-2.8182	-1.8622*	-2.4156	-1.8184*
SIZE	-0.0001	-0.2496	0.0006	1.6655*	0.0007	2.6824***
AGE	-0.0107	-0.8018	-0.0304	-1.6572*	-0.0197	-1.3425
ED	0.8621	2.1693**	1.6722	3.5084***	0.8101	2.5041**
OWN	0.0500	0.1658	0.4884	1.1596	0.4384	1.2933
PTIME	-0.5308	-1.6811*	-0.7007	-1.5311	-0.1698	-0.4499
DAIRY	-0.1847	-0.4646	0.6860	1.3020	0.8707	2.1053**
TENANCY	0.2157	0.6740	0.6372	1.3986	0.4215	1.1378
FR	1.1124	2.5549**	1.5949	2.2478**	0.4825	0.7437
MR	0.4472	1.4731	1.5600	3.3692***	1.1128	2.8391***
ER	1.0645	1.5451	0.1391	0.1289	-0.9254	-0.9020
Model Chi-square	73.320					
Pseudo R-Square[c]	0.161					
Change in Probabilities[d]						
SIZE	-0.00002		0.00002		0.00004	
AGE	-0.00226		-0.00090		-0.00124	
ED	0.20456		0.11465		0.07302	
OWN	0.01069		0.01857		0.03366	
PTIME	-0.09979		-0.01539		-0.01002	
DAIRY	-0.03766		0.02876		0.08051	
TENANCY	0.00046		0.00019		0.00027	
FR	0.26666		0.10529		0.03776	
MR	0.10196		0.10123		0.11382	
ER	0.25489		0.00447		-0.03995	

[a] Group 1 = no records, 2 = manual, and 3 = computer-based accounting systems.
[b] Ratio of the coefficient to the asymptotic error.
[c] See Aldrich and Nelson, page 57. This measure of goodness of fit ranges between zero and one. It does not incorporate a correction for "degrees of freedom."
[d] Change in probabilities resulting from a one unit change in the indicated variable with all other continuous variables constant at their mean and with all other binary variables constant zero.
* One, two, and three astrisks indicate significance at the 0.1, 0.05, and 0.01 level of probability, respectively.

Age of the primary decision maker was hypothesized to influence the selection of an accounting system for a variety of reasons. The life cycle hypothesis suggests that the manager's goal structure may change with age. Thus, changing age may affect value of information derived from an accounting system. Moreover, experience, typically highly correlated with age, may serve as a substitute for information for certain classes of decisions and may reduce demand for elaborate information systems. Increased age may also be associated with an unwillingness to adopt new information technologies--particularly computer-based technologies. The estimated regression coefficient for AGE is significant only for the comparison of computer-based accounting systems relative to manual systems. Older farmers, it seems, tend to prefer manual records.

Education is incorporated as a measure of human capital. Additional education, it was hypothesized, increases understanding of the complexities of production relationships and leads to an increased demand for information. Better informed individuals are more likely to appreciate the value of information. Furthermore, more highly educated managers are more likely to have the prerequisite knowledge required to maintain and interpret accounting information and to be able to use computerized information systems.

The estimated coefficients suggest an important role of education in the selection of the accounting system. The presence of a college education (ED = 1) increases the probability of a manual system relative to no accounting system, increases the probability of having a computerized accounting system relative to no system, and increases the probability of having a computer system relative to a manual system.

The number of owners of the firm is hypothesized to influence the decision making apparatus. As the number of owners increases, so does the rigor required of the accounting system. More owners typically mean more accounts and a greater need for a formalized reporting procedure. Although number of owners was hypothesized to be a significant determinant of accounting system type, the estimated regression coefficients were not significant in any of the equations.

Part-time farmers also were hypothesized to have different accounting needs. Part-time farmers have less time to complete tasks. Competition for time may mean relatively less time is available to maintain and interpret accounting records. The estimated regression coefficients for PTIME were significant only for one of the three equations. This estimate suggests that part-time farmers are more likely to have a system of only bills and receipts than to have a manual accounting system.

Primary farm enterprise type was hypothesized to be an important determinant of accounting needs. To test this hypothesis, dairy farmers are identified with a binary variable. Estimated coefficients indicated that dairy farmers are more likely to have a computer-based system than a manual accounting system. There are no significant differences by farm type in relative probabilities of no accounting system versus computer and manual systems.

Tenancy is a continuous variable which measures the proportion of the total land base controlled through cash or share lease. Increased tenancy was hypothesized to increase the demands on the accounting system. Increased tenancy may mean more landlords. A larger number of landlords generally means more detailed records must be maintained. With share lease arrangements, income and cost-sharing must be documented for each landlord. For this reason, it was hypothesized that increased tenancy would be associated with demand for more complex information systems. However, tenancy was not significant at the critical level of probability for any of the three equations.

The final three binary variables consider alternative uses of accounting information. FR measures preparation of financial reports. If financial reports are prepared, the probability of both manual and computer-based systems increases relative to a system of only check stubs, bills, and receipts. These analyses require more complete transactions data and summary techniques.

Similarly, the generation of budgets, cash flow projections, and other management reports (MR) place greater requirements on the accounting system. Farmers who use accounting information to generate management reports tend to prefer computer-based accounting systems, both relative to no system and to manual systems.

ER, a binary variable indicating the use of accounting records to facilitate external reporting, was not significant in any of the three equations. This may be due, in part, to a lack of variability in this variable. Over 90 percent of the respondents indicated that the accounting records system was used to support external reporting activities. This is predominated by tax reporting. However, other types of reporting were frequently cited.

Conclusions

Analyses of survey results indicate that farmers of different sizes, ages, and education levels employ different types of information sources. The relatively informal sources of radio broadcasts and general farm magazines are the two most frequently cited sources by usefulness. Highly formalized and market-specific sources such as market consultants, commercial advisory newsletters, and computerized information sources are cited relatively infrequently. The relatively high evaluation scores for broadcast media, other farmers, and individuals suggest that these informal information sources have perceived value for farm decision making.

There also were substantial differences in the way different subgroups within the sample evaluated information sources. Larger farms ranked more highly commercial newsletters, marketing consultants, the CES, and brokerage firms than did smaller farms. Older farmers ranked specialized farm magazines higher and commercial newsletters and brokerage firms lower than did younger farmers. Evaluations for national newspapers, radio broadcasts, accountants, attorneys, salesmen, veterinarians, and other farmers differed with education level.

Important variables explaining accounting system choice were use of reports, farm size, and education level. Also, farm type influences uses of accounting reports. Grain farms tend to use accounting reports to monitor cash flow, while dairy farms tend to use accounting reports to analyze profitability.

These results hold important implications for regional project NC-191. Farmers currently use a variety of information sources. Their internal records systems vary greatly in terms of organization and use. Before this project can begin to develop standards for database and model base design, it is important that we first understand the heterogeneous demands that farmers place upon their information systems.

Notes

1. Although the weights assigned are arbitrary, they provide an ordinal index by which an individual's evaluation of alternative information sources can be judged. Comparison among individuals is more difficult, however, because (1) individuals may interpret the response scale differently and (2) individuals subscribe to different numbers of sources. A standardized response scale was developed to reduce these distortions. However, there were no important differences in the usefulness score rankings between the standardized and unstandardized indices. Because the unstandardized scores are more easily interpreted, they are reported.

2. Farmers were asked to indicate whether their access to information was adequate for various decision types. Nearly 83 percent of the grain farmers indicated their access to production information was adequate. Just under 74 percent indicated their financial information was adequate and almost 78 percent thought weather information was adequate. Marketing information received the lowest adequacy rating, with only 69 percent of grain farmers indicating their market information to be adequate for their needs.

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SELECTING A SAMPLING FRAME FOR SURVEYING FARM OPERATORS' USE OF MANAGEMENT INFORMATION SYSTEMS

David L. Watt and Gary A. Goreham*

The use of computers among farm operators has grown substantially since the introduction of personal computing. Of particular research interest are the uses farm operators may be making of computerized management information systems (MIS). Selecting a representative random sample of farmers to study MIS has proven problematic for researchers. At least two reasons may be noted for this difficulty. The first problem is that of obtaining a representative sampling frame of farmers. The second problem is that of obtaining a representative sampling frame of farmers who use computers.

This paper presents the management information systems (MIS) framework. Because the MIS framework consists of a variety of components, researchers need to remain cognizant of which components are important to their studies. Selection of the components to be included in a research project provides an important basis for selecting sampling frames. Several sources of MIS sampling frames are discussed and evaluated below.

Farm Operator Populations and Sampling Frames

One of the first steps researchers need to take in a study of farm operators' MIS use is a determination of their *units of analysis*. That is, they need to select what or whom they wish to analyze. Are they intending to study farms, farmers, or farm households? In addition, they need to specify the geographic region in which their respondents are to be found. For example, they may select all farming operations in State A, all farm households in Planning Region B, or all farmers in County C.

Having determined their units of analysis, the researchers must next select their *population universe*. The population universe consists of all the units or individuals who have certain characteristics and that are located in a specific geographic area. For the purposes of our discussion, we shall focus on two populations: (1) all farm operators in a specified geographic area and (2) all farm operators in a specified geographic area who use computerized management information systems. Each of these are discussed below.

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Typically, a population universe contains far more individuals than can be surveyed or need to be surveyed. A sample of these individuals may be used if the sample is representative of the population universe. A random selection of individuals from the population is one method used to obtain a representative sample. However, this method presents a problem to researchers. Rarely do they have the names of each member in the population universe, nor do they have sufficient information to contact each one.

Some source must be found for a list of names, addresses, and/or telephone numbers for the members in the population universe. This list is the *sampling frame.* It is from the sampling frame, not the population universe, that the *sample* is drawn (Figure 1).

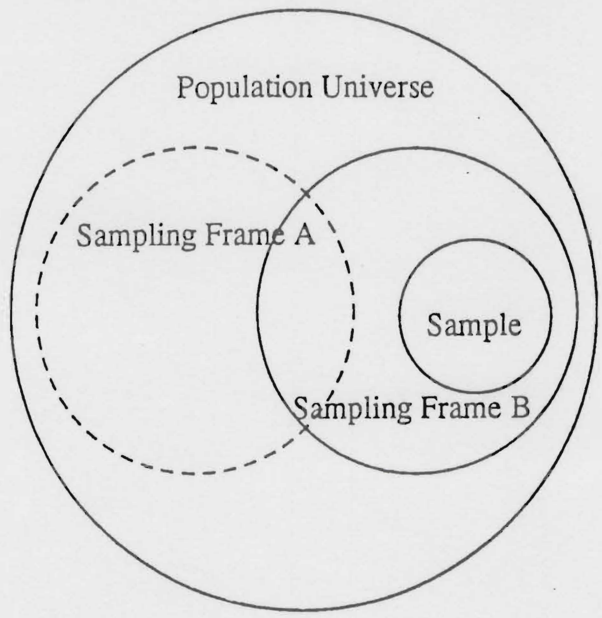

Figure 1. Population Universe, Sampling Frames, and Samples

The names on the lists obtained from various sources do not always match the actual names of those individuals who make up the specific population that the researchers may hope to study. The lists may contain individuals who are not members of the population universe. Or, the lists may not contain all of the names of the population universe. Either of these conditions may present problems to researchers as they attempt to demonstrate that the sample is representative and that the subsequent study's findings may be generalized to the desired population universe.

Types and Levels of Management Information Systems

Agricultural management information systems (MIS) are comprised of planning systems on four levels: strategic systems, tactical systems, operations systems, and transaction processing. Researchers must determine which of these levels they wish to investigate. The following discussion describes the various levels of MIS as they relate to farming operations.

Farm operators' management responsibilities may be categorized into a number of functional areas. Some of these include marketing, engineering, production, purchasing, and accounting. The various levels of the MIS hierarchy are applicable for each of the functional areas as depicted in Figure 2.

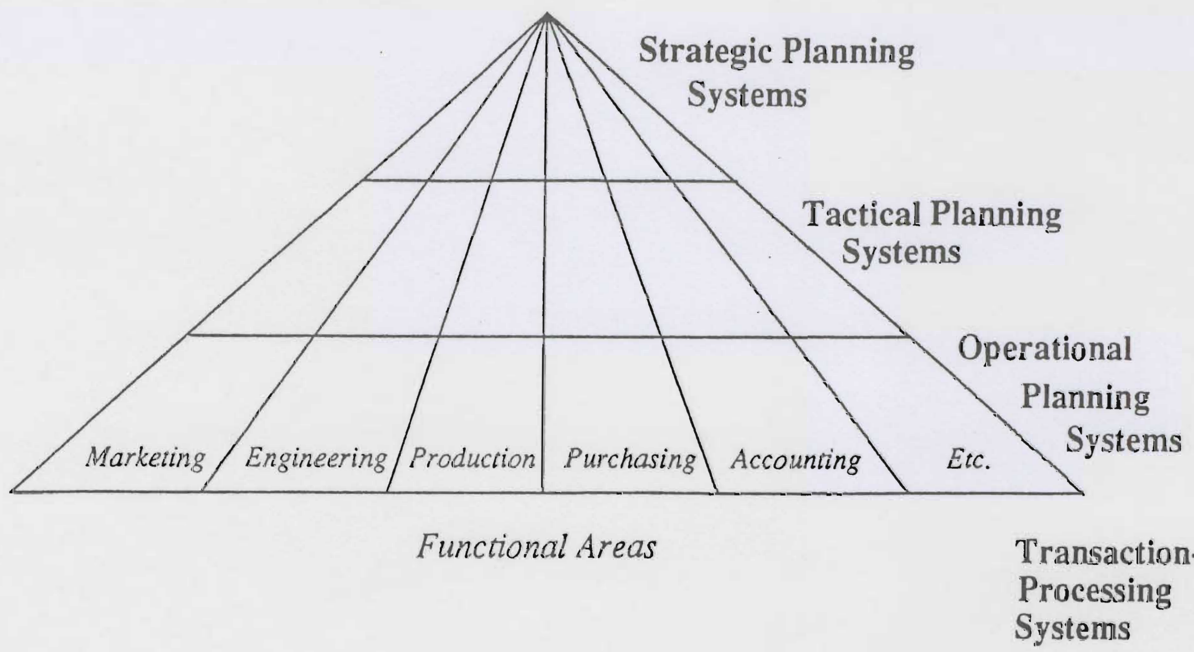

Figure 2. Management Information Systems Hierarchy and Functional Areas
Adapted from Scott (1986) and Shore (1988)

A description of the information systems for each of the functional areas will prove helpful when selecting a sampling frame. The management information system (MIS) hierarchy may be listed by each of the functional areas and will result in a classification of information characteristics to each functional area. The classification provides the information needed to consider what impact a particular sampling frame may have on research results.

The functional areas of production, marketing, purchasing, accounting, and engineering are aspects of the information system that could be surveyed. Research may be conducted on any of these functional areas for each level of management. Each block in the resulting management matrix blocks will require unique research data (see Table 1). The sampling frame that is selected will affect the findings of a survey intended to measure a particular block in the MIS-functional area matrix.

Table 1. Management Information System Matrix

		Management Level			
	Functional Areas	A Strategic Planning	B Tactical Planning	C Operations Planning	D Transaction Processing
1.	Production	A1	B1	C1	D1
2.	Marketing	A2	B2	C2	D2
3.	Purchasing	A3	B3	C3	D3
4.	Accounting	A4	B4	C4	D4
5.	Engineering	A5	B5	C5	D5

Transaction processing (see column D of Table 1) is the record system for routine business activities. It is a system that is best handled by standard operating procedures and does not require complex decision making. Examples of transaction processing on a farm operation may include bookkeeping, machinery maintenance records, grain tickets, and field or herd records. All of the management information needed to make decisions is usually available on the site of the farm itself. This type of management information may be obtained through observation or through papers and records available on farmsite.

Operations planning (see column C of Table 1) refers to the information needed in the management of normal day-to-day operations. The daily plan of work is organized at this level. Examples of information at this level include locations of farm equipment, operational readiness and capacity of each piece of equipment, amount of money in the bank, market activities, and availability of suppliers and supplies.

Tactical management (see column B of Table 1) solves problems like getting crops planted, calves sold, marketing information gathered, and crop inputs acquired in a given period of time. The objective of such management concerns would be to make decisions that would cover agricultural production cycles.

Strategic management (see column A of Table 1) determines if the performance of the firm is optimal and what action should be taken if performance is not as desired. This management level often looks at changes in capital ownership, financing strategies, entry or exit from activity in a specific enterprise, and adoption or development of a new technology.

Each of the functional areas has unique information needs. In moving across the spectrum from strategic planning to transaction processing, decision making becomes more routine. In MIS terminology, it becomes more "structured" or "programmable." Highly structured problems have well-defined information needs and easily articulated decision rules. In contrast, unstructured problems require a broader scope of information and typically require an MIS that allows for ad hoc retrieval request (Davis and Olson 1986).

In addition, to support decisions at the strategic planning end of the spectrum, more external information is needed in contrast to the largely internal sources used for transaction processing.

The matrix presented in Table 1 is intended to help define the research objective of the proposed survey. In addition, it can be used to help evaluate the appropriateness of various potential sampling frames. In particular, certain frames may be biased toward certain areas in the matrix. The following section attempts to identify potential biases in various specific frames.

Sources of Sampling Frames

Several sampling frames may be established for any given population universe. Most frames are associated with varying MIS characteristics. The sampling frame needs to be carefully analyzed with reference to the kind of MIS information to be gathered for the best fit in subsequent analyses.

Which sampling frame is selected depends on its relative merits according to the nature of the study. The following discussion describes some of the advantages and disadvantages of selected sampling frames that may be obtained from various sources, along with the types and levels of information most amenable to the members of these frames.

All Farmers in a Specified Geographic Area

Researchers may wish to conduct a survey in a geographic area using farm operators as their unit of analysis. For example, they may wish to determine how many farmers are using computers for agricultural purposes, and to what avail. Some of the sampling frames described below use farm operators as their units of analysis, while others use farm households or farm operations as their units of analysis. When researchers wish to use aggregated data, other sources of information may be available but are beyond the scope of this discussion.

Agricultural Stabilization and Conservation Service (ASCS). The ASCS has long been a useful source of names, addresses, and telephone numbers of farm operators. They are typically quite willing to provide lists of operators to researchers free of charge on computer tape or on mailing labels. Their willingness to cooperate, however, depends on the use the researcher intends to make of the data. The sampling frame available from the ASCS would consist of all farm operations participating in federal farm programs. This has recently consisted of the majority of all farmers.

The ASCS sampling frame holds a couple of potential drawbacks for researchers. First, not all farmers participate in federal farm programs. Thus, if the population universe under consideration is all farmers, using the ASCS list as the sampling frame would exclude some farmers. Further, those on the ASCS list would primarily be crop producers rather than livestock producers.

Although the sampling frame available through the ASCS consists of the names and addresses of farm operators, it is derived from farm operations as opposed to farm operators. The ASCS list is a compilation of farm operations currently participating in farm programs where each farmer is limited in the amount of money he/she may obtain from a federal farm program. To get around the limitation, some farmers have created "paper farms" under the names of other family members who may or may not be farming.

Lists of farmers' names are available from county ASCS offices rather than from centralized, statewide offices. The logistics of contacting each county office to obtain lists may counterweigh the advantages of using the ASCS lists.

Farm operators typically make use of ASCS services for crop planning. Thus, tactical planning information systems may be most appropriate for surveys using ASCS sampling frames.

National Agriculture Statistics Service (NASS). The National Agriculture Statistics Service (NASS) endeavors to maintain a list of the farmers in each state. A primary source for the NASS list is the ASCS list collapsed to farmers instead of farms. Other sources of names for the NASS list include any others they can legally incorporate, such as checkoff and commodity groups. Responses to surveys are used to update the NASS list.

When farmers in North Dakota indicate that they intend to stop farming,a telephone follow-up is made to determine who may be replacing them. The North Dakota list represents over 90 percent of the farmland in the state. Other states have varying levels of coverage.

The NASS cannot give out names. However, they will perform the mailing and follow-up uniformly across states. The procedure is to indicate the size of the sample and the characteristics of the sample population. The NASS performs the random selection. Names and addresses are made available to the researchers that do the mail-out. If a telephone interview method is chosen, the NASS can conduct the interviews on a fee basis. The names of the respondents are not provided with the survey results. NASS retains the right to censor items on the questionnaires or may require that particular items be included.

The NASS frame is farm operators rather than farm operations. Thus, the NASS list appears to be the most general sampling frame for all elements of the MIS matrix.

Purchased Lists. Purchased lists are available from a number of marketing firms. For example, the Webb Publishing Company in Minneapolis, Minnesota, sells a list of corn producers in a three-state area for about $700. The list includes about 2,000 names. These lists are typically available on computer tape and mailing labels.

One caution that needs to be raised regarding purchased lists pertains to when the lists were created. Researchers need to determine how current the lists are and how the lists were developed. Purchased lists can be outdated. There is the potential for names no longer in the population universe to remain on the sampling frame. An additional disadvantage of purchased lists may be their cost.

Farmers Home Administration (FmHA), Farm Credit Services, and Banks. In the case of FmHA, state FmHA offices should be contacted by letter requesting a list of borrowers. This list must invoke the Freedom of Information Act and state the purposes for which the list will be used. FmHA lists are usually free of charge unless the total bill exceeds $25. The fee may be waived if it will be used for what FmHA officials deem to be a good cause. Currently, FmHA is allowed to release only the names and addresses of its borrowers. Previously, since FmHA provided federal government loans to private entities, they could also release the amount of each borrower's loans and delinquency. This policy is under review by the Supreme Court. In the case of banking institutions, lists of names may not be available to the public.

These sampling frames list only those farm operators who have dealings with the institution. Thus, the information required by the various institutions will receive undue emphasis in survey responses. MIS research topics most pertinent to these sampling frames will likely be topics of relevance to the functional areas of accounting and finance.

State Tax Departments. State tax department lists are comprised of individuals filing a Schedule F. They may include all farm operators by enterprise level. The lists will probably be free, <u>if</u> the various state tax departments are willing to release them. When state tax departments are willing to make their lists available, they generally require evidence of strong public need for the release.

One problem with the use of Schedule F is that occupational category of the filer depends on self-report.

Economic Research Service (ERS). The ERS conducts a Farm Cost and Returns Survey on a large, nationwide sample. Significant resources are available from the federal government to the ERS to complete this survey. For MIS research, this sample frame would likely focus on finance functions.

The ERS does not release its list of respondents, but may be willing to include items on its survey. Experience indicates that the willingness of the ERS to cooperate in adding questions may increase if there is meaningful involvement of agricultural economists from ERS. Once the survey has been completed, there are strict limitations on data availability.

Soil Conservation Service (SCS). The SCS is continually in the process of updating its list of farmers' names and addresses on a county basis. They do not maintain telephone numbers. Their lists are based on farm operators involved in soil conservation programs. In some counties, the involvement may reach as high as 90 percent of the farm operators.

Although their lists may be inexpensive, they include only those involved in soil conservation programs.

List of Names from County Extension Agents. Of those who have knowledge of the farmers in a county, extension agents usually rank near the top. Their knowledge is current and they do not charge to help create lists of names. Once an agent has provided a list of names, researchers must independently obtain addresses and phone numbers unless the agent maintains county mailing lists. The type and level of MIS research would likely involve production and some marketing and accounting across all MIS categories.

Unfortunately, agents' knowledge of farmers' names and addresses may be skewed toward those with whom the agents have most regular dealings. As a result, sampling frames derived with the assistance of county extension agents may amount to an "opportunity" sample. Lists of names obtained from county extension agents may depend on the amount of time and effort he/she puts into building it. Additionally, coverage and accuracy of the lists depend on how long an agent has been in a county, how well he/she knows the farmers, and in which extension programs the agent and the farmers are involved.

County Atlases. Counties maintain atlases of farmers by township and section within their jurisdiction. Information gleaned from this source is free of charge and is generally all-encompassing.

A number of disadvantages may be noted from this source of sampling frames. First, locating the names in a county atlas is labor-intensive and time-consuming. Second, the names are not always current. Finally, the frame would be oriented to land ownership. Locating owners through the mail may be difficult.

Farm Record Keeping Associations. Several states have record keeping associations sponsored by their land-grant universities. One example is the Illinois FBFM. In addition, most states have similar businesses in the private sector.

Lists of individuals who have used these services are self-selected and, thus, may differ from the larger population of all farmers. Nevertheless, there are advantages to such lists. The financial information drawn from these sources tends to be more accurate and standardized than that of the general farm population. Also, it may be possible to obtain short time-series data on the records for a panel of such farmers.

All Farmers in a Specified Geographic Area Who Use Computers for Agricultural Purposes

Of particular importance to researchers of agriculture-related MIS is the development of a sampling frame of farmers who use computers for agricultural purposes. The following discussion describes some potential sources for these sampling frames.

Agricultural Computer Magazines. General farm magazines are published that may provide researchers with subscription lists of farm operators. Examples of these magazines include The Farmer and Successful Farming. Farm magazines are also published that may be specific to certain types of farm operations. Some of these magazines include The Sunflower and Hoard's Dairyman. Similarly, a number of magazines are available on the topic of agricultural computer applications. Subscribers would consist of individuals actively interested in using the computer for agricultural purposes. A sampling frame consisting of subscribers would include those who have spent more time than most on considering computer use in management.

Subscribers to these magazines typically provide only their names and addresses. Further, it is unlikely that sampling frame sizes would approximate the population universe size. To obtain a free copy of a magazine's list of subscribers, researchers would need to do an analysis of the magazine's interest areas. If the magazine's officials see the request for their list of subscribers as a source of revenue, it could be costly.

County Extension Agents. As described above, county extension agents typically have access to a large amount of information on the farm operators in their counties. This knowledge may include a listing of those farmers who use computers in their farming operations. Because of the farmer-agent trust relationship, the list of farmers may likely include those who are more responsive, thus insuring a higher return rate and higher quality of responses to questionnaire items.

Although county extension agents have a large amount of information about their clientele, they may not know all of the farmers who use computers for their farming operations. Thus, there are limitations to county extension agents as sources of sampling frame.

Computer Hardware Sales Dealers. Computer hardware sales dealers are not usually located in smaller, rural communities. Nevertheless, they are likely to know the names of their customers in sparsely populated areas. The information they have available may be biased toward specific brand names or physical characteristics of a machine.

There are limitations on sample frames obtained from computer hardware sales dealers. This is particularly true if farmers purchased their computer elsewhere. Further, dealers may be most likely to name only those computer owners with whom they have the most contact.

Computer Software Sales Dealers. Besides computer hardware dealers, computer software dealers may also have access to lists of farmers who use computers for agricultural purposes. One advantage to their lists is that they can focus on computer users who have experience using the same software package. Software dealers' lists may be most appropriate for MIS research pertaining to transaction processing.

Sampling frames derived from software dealers have a number of potential disadvantages. First, dealers' lists may be limited because farmers could have purchased their software elsewhere. Secondly, the results of research using software dealers' lists could have an applications bias.

Sales Computer Extension Specialists. State computer extension specialists develop agricultural application software literature for their clientele. They frequently conduct workshops on use of agricultural computer applications throughout their states. They maintain lists of individuals to whom they have sold computer software to or who attended their workshops.

As with other Cooperative Extension Service staff, their assistance will be free of charge. They will probably be very willing to help with an MIS research project. If these individuals can be involved at an early stage of the project, they may be more likely to apply the results in their own work.

Unfortunately, these specialists will not have a complete listing of all farm operators who use computers for agricultural purposes. And, since the frame they helped to develop is related to Extension, the results could be of more use to Extension than it will be to the general population.

Two-Step Survey Method. Another method of obtaining information on farm operators who use computers for agricultural purposes is the "two-step" survey method. This method involves sending a survey card to farmers asking them if they use a computer for their farm operations. If so, they are then asked to complete a computer use survey.

This method is likely to be cost-prohibitive. Further, it is likely to yield a low response rate. Hence, the method raises questions of how representative of the population universe the sample may be. It also raises questions on the validity of the study.

List Convergence. Sometimes it may be necessary to assure that the sampling frame approximates the population universe as closely as possible. To do this, the researchers may wish to select several sampling frames. They may then converge the lists and eliminate duplicates.

Conclusion

The selection of a sampling frame is significantly dependent upon the information desired. This paper has presented a matrix of the domain of MIS. The cells of the matrix can serve as a focal point for a delineation of the material to be studied. If the primary purpose of the study is descriptive, this framework helps to identify possible bias within specific cells. However, if hypothesis testing is the goal of the study, the paradigm will assist in the selection of appropriate populations.

Studies of MIS often focus on a single functional area. Studies of computerization tend to focus on transaction processing or on very specific decisions such as land rent, farm programs, or crop disease diagnosis. Most of this work has been problem-oriented and, therefore, has been interested in exploring the domain of MIS applied to farms. An MIS study should explicitly decide on the aspects to investigate.

The selection of a sampling frame should occur *after* the research design has taken place. That is, the researchers first need to determine what they want to study, what will be their dependent and independent variables, and how best to obtain their information (e.g., mail-out/mail-back questionnaires, personal interviews, or telephone interviews). Having completed this step, they are then in a position to decide what sampling frame would best suit their purposes. Thus, selection of a sampling frame is dependent upon which segment of a population universe will most likely provide the type of information necessary to answer the research questions.

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STRATEGIES FOR INFORMATION REQUIREMENTS DETERMINATION

Robert P. King and Craig L. Dobbins*

Computerized management information systems (MIS) support and extend managerial capabilities by automating information processing tasks. Record systems help organize, store, and retrieve information quickly and efficiently. Exception reporting systems can monitor conditions and performance in several aspects of a business without suffering from information overload or a lapse in attention. Budgeting models can perform complex calculations more quickly and accurately than any manager.

The potential for computerized MIS to improve management in farm businesses is great, but that potential has not been realized on a widespread basis. One reason for this difference between what is and what could be is that both managers and agricultural software developers often lack a realistic, accurate understanding of information system needs.

Identifying information system needs for any business is difficult for at least two reasons. First, knowledge of business processes and information technology rarely resides in the same person. Few managers have a good understanding of current computer hardware and software technology, and few software developers have an in-depth understanding of the management processes their products will support. Second, even when managers and software developers work together to identify information needs, they often have difficulty communicating. When asked to describe what they do and how automation of information processing tasks may help them, managers often find it hard to respond because the important, but routine, tasks that are the best candidates for automation are often done unconsciously.

The problem of information systems requirements determination has been a central issue on MIS research over the past fifteen years. Farm management researchers and extension specialists concerned with farm information systems development and adoption have not drawn extensively on findings from that research, however. In this paper we present a general introduction to the literature on MIS planning and requirements determination. We base our discussion on the literature review presented by Davis and Olson (pp. 443-528). We then explore the applicability of findings from that research for MIS planning and requirements determination in farm firms and suggest a workshop format for testing alternative requirements determination strategies with farmers.

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Information Systems Planning

In a farm operation, the adoption of a computerized information system is a strategic decision. In general, there are significant start-up costs for hardware, software, and training; and, because information systems evolve as they are used, initial decisions can have important impacts on long run costs and benefits. Long range planning for information system needs can be useful in any organization, but it is particularly important in organizations taking their first steps toward a formalized MIS.

Davis and Olson (pp. 447-50) identify four major components of a long range information systems plan. They are: (1) a statement describing information system goals, objectives, and architecture; (2) an inventory of current capabilities; (3) a forecast of developments expected to affect the plan; and (4) a specific plan for hardware, software, and training investments.

The overall architecture of a firm's MIS describes the purposes the MIS is intended to serve and identifies the major application and database subsystems it will include. For example, the major functions of the MIS in a large cash crop operation might be to support production management decisions at the field level, marketing management, and the preparation of annual financial statements for lenders and income tax preparation. The major components of the MIS for such a firm might be a field record system, an on-line market news service, and an accounting system. Like a good overall business strategy, a good information system architecture should be specific enough to provide definite direction, yet flexible enough to allow the firm to adapt to changing business opportunities.

The inventory of current MIS capabilities should be a realistic assessment of how well the firm is meeting the goals and objectives identified in the information system architecture. For example, in our hypothetical cash crop operation, it might include a description of existing field record and financial data and an evaluation of marketing management skills needed to make effective use of more timely, detailed market information.

The forecast of factors expected to affect the MIS plan should include descriptions of possible changes in the organization that could affect information needs and some assessment of the effects changes in information technology are likely to have on the firm's MIS. For example, the possibility of joining a commodity marketing pool would certainly be an organizational change that would affect marketing management information needs. Similarly, the possibility of a shift to new operating systems for personal computers is a technological change that should at least be considered by farmers evaluating hardware and software investments.

Finally, the specific plan for information system investments should identify major hardware and software purchases and projected information system expenditures. It should also lay out a timetable for purchases, installation, and training.

The development of a long range information system plan can be a complex, intimidating process for small firms. The three-stage information system planning model proposed by Bowman, Davis, and Wetherbe provides useful insights on the general structure of that process and can serve as a guide in the selection of planning tools to facilitate it. The three stages in their model are: (1) strategic planning, (2) organizational information requirements analysis, and (3) resource allocation.

During the strategic planning stage of the MIS planning process, primary emphasis is placed on specifying objectives for the information system and on clarifying the relationship between the information system plan and the overall strategy for the organization. Bowman, Davis, and Wetherbe identify two phases in the organizational information requirements analysis stage of the planning process. During the first phase, current and projected information needs are assessed for major activities in order to develop an overall information architecture for the organization. During the second phase, a master plan for information system development is derived from the information system architecture. Finally, during the resource allocation stage, plans and budgets for hardware, software, and training investments are made.

Bowman, Davis, and Wetherbe note that no single information system requirements determination strategy is generally well suited for use in all three stages of this process. They use their three-stage model as the basis for recommending an appropriate mix of methods. In the next section, we discuss the strengths and weaknesses of four general requirements determination strategies and describe two commonly used methods that we believe are potentially well suited for use with farmers.

Strategies for Identifying Information Requirements

Davis and Olson (pp. 480-88) identify four general strategies for determining information system requirements: (1) asking, (2) deriving requirements from existing information systems, (3) synthesizing requirements from the characteristics of the processes being managed, and (4) discovering requirements through experimentation. Clearly, asking managers about their information needs is the most direct of these strategies, but managers often find questions about information requirements difficult to answer. Asking strategies, be they based on structured interviews or open-ended discussions, almost always need to be used in combination with other strategies. Often, careful examination of existing information system components within the organization or in similar organizations can provide useful information on information system requirements. A deriving strategy of this kind can be further supplemented by careful investigation of the features of hardware and software products on the market. One problem with deriving strategies is that they can focus attention on technical features of particular application subsystems rather than on their suitability in the context of the organization's activities. Synthesizing strategies help focus attention on the business processes to be supported by the MIS. They usually are based on structured investigations of organizational activities, followed by a mapping of organizational characteristics into desired MIS characteristics. The basic features of two synthesizing strategies are reviewed later in this section. Each has the advantage of helping managers gain a better understanding of their businesses. They share the disadvantage of usually requiring some outside expertise. Finally, determination of information requirements through experimentation or prototyping can be quite effective when a manager and system designer can work together closely on the development of a new information system application. This approach is not well suited, though, for requirements determination in small firms that will not be using internally developed applications.

In the remainder of this section, we briefly describe two commonly used methodologies for synthesizing information system requirements from organizational characteristics: the strategy set transformation approach and critical success factor analysis. These are representative of commonly used systems analysis tools and, with some modification, each may be appropriate for use with farmers.

Strategy Set Transformation

The strategy set transformation approach to information system requirements determination was developed by W.R. King as a method for matching MIS goals and strategies with organizational goals and strategies. As such, it is particularly well suited for use in the strategic planning stage of the MIS planning process. Under this approach, requirements determination begins with the identification of organizational goals and the formalization of strategies for meeting them. Organizational attributes that may affect the MIS strategy are also identified. Attention then shifts to the development of an MIS strategy for the organization. MIS goals, factors that may limit the range of strategic alternatives for the MIS, and specific elements of an MIS design strategy are identified. These are derived from and linked explicitly to the organizational strategy.

Organizational and MIS strategies for a hypothetical cash grain operation are outlined in Figures 1 and 2 to help illustrate this approach. Organizational goals are listed in the left-hand column of Figure 1. Key elements of the strategy for achieving these goals are shown in the middle column of Figure 1. Organizational goals to which each strategy element is linked are indicated in parentheses. Finally, organizational attributes likely to have an impact on the MIS strategy are identified in the right-hand column of Figure 1.

The MIS strategy for this operation is outlined in Figure 2. MIS goals are listed in the left-hand column. Each is linked to elements of the organizational strategy identified in Figure 1, emphasizing that MIS goals are determined by the needs of the organization. Similarly, MIS constraints listed in the center column of Figure 2 are linked to organizational goals, strategies, and attributes. Finally, the MIS design strategies listed in the right-hand column of Figure 2 identify specific actions for achieving MIS goals.

The most difficult challenge for managers using the strategy set transformation approach is in making the transition from an organizational strategy to an MIS strategy. This approach provides a framework for structuring ideas and for showing the linkages between the two strategies, but it provides little direction on how to identify the most appropriate MIS strategy. Managers are often able to specify MIS goals and constraints, since these are best expressed in terms that are closely related to organizational goals, strategies, and attributes. They will often need the help of an outside specialist, however, in formulating an MIS design strategy. The job of that specialist will be made easier by a clear statement of the organizational strategy and by experience with similar firms.

Organizational Goals	Organizational Strategies	Strategic Organizational Attributes
O_1: 6 percent average annual increase in net farm income	S_1: expand acreage by renting land (O_1,O_2)	A_1: good commodity marketing skills, member of marketing club
O_2: maintain debt asset ratio below 30 percent	S_2: exercise tight control on production costs (O_1)	A_2: excellent field records have been maintained manually
O_3: reduce income variability	S_3: use crop insurance and forward pricing to manage risk (O_3)	A_3: wife has some computer training
	S_4: add a custom grain hauling enterprise (O_1,O_3)	A_4: active computer user group at AVTI
		A_5: accurate financial statements required by lender

Figure 1. Organizational Strategy for a Cash Grain Operation

MIS Objectives	MIS Constraints	MIS Design Strategies
MO_1: improve cost control and production management in crop production (S_2,A_2)	C_1: system must be consistent with existing production and marketing records (A_1,A_2)	D_1: computerize production records first; try to choose a vendor that also sells an accounting package (S_2,MO_1,C_1,C_2)
MO_2: improve information used for commodity marketing management (S_3,A_1)	C_2: production and cost information must be integrated for crops (O_1,MO_1)	D_2: get involved in marketing club's effort to computerize price records (A_1,MO_2,C_1)
MO_3: maintain sound financial records for cash flow mangement and annual financial statement preparation (O_2,A_5)	C_3: financial report formats must meet lender and IRS requirements (A_5,MO_3)	D_3: continue manual accounting system for at least one year (MO_3,C_3,D_1)
		D_4: purchase a computer system with adequate expansion capability (D_1,D_3)
		D_5: purchase a modem and arrange for trial subscription to an on-line agricultural database service (MO_3,C_1)

Figure 2. MIS Strategy for a Cash Grain Operation

Critical Success Factor Analysis

Critical success factor analysis (Rockart) is a method that has been widely used to help general managers in large organizations identify their most important information needs. Bullen and Rockart (p. 7) define critical success factors (CSFs) as:

> ... the limited number of areas in which satisfactory results will ensure successful competitive performance for the individual, department, or organization. CSFs are the few key areas where "things must go right" for the business to flourish and for the manager's goals to be attained.

Fairly specific information requirements can be synthesized from a set of CSFs by asking what information is needed to determine whether performance in these key areas is satisfactory and what information could contribute to significant improvements in performance in each area.

To be useful, CSFs need to be specific and truly critical to the success of the business. Usually there is a hierarchy of CSFs, one set for the organization as a whole and more detailed, narrowly focused sets related to particular activities. CSF analysis can, then, be used during the strategic planning stage of the MIS planning process or during the organizational information requirements analysis stage. Its contribution is most important, however, in the second of these two stages.

CSFs for crop production management in our hypothetical farm firm will help illustrate the concept of CSFs and their usefulness in defining information needs. Cost control, timeliness of spring field operations, and yield risk reduction would be three typical CSFs for crop production management. They suggest several areas where information may have a significant impact on performance and several questions that, when answered, will help clarify information needs.

Regarding cost control, for example, the causes of cost mistakes need to be identified. They may include failure to control pest or excessive pesticide use, ineffective machinery maintenance and repair, or paying too much for important inputs. Clearly, these potential causes of costly mistakes are the factors that need to be monitored most closely. Key control points also need to be identified. Can significant adjustments be made during the growing season to control cost? If so, the timeliness of information on key items affecting unit costs will be important. Often, though, the best time to prevent serious problems is before the growing season, which makes timeliness less important. Finally, the complexity of the cost control problem needs to be assessed. As the number of fields and rental units increases, keeping track of factors affecting costs becomes more difficult and timely production reports and action lists become more important. Field record systems that keep track of inputs, production levels, and costs can provide a structure for organizing, recording, and analyzing data needed for effective cost control, but the characteristics of that system and the need to computerize it will depend on the potential for information to improve management decisions.

It is important to note that better information and information systems are not the only ways to improve performance in critical areas. CSF analysis is more than a mechanism for identifying information needs. It is also an activity that helps managers consider a wider range of alternatives for improving performance. It should also be noted that, as with the strategy set transformation approach, managers often need to consult with a technical expert or reliable vendor before a final determination of information needs can be made. Identification of CFSs and an initial assessment of information needs can provide a structure for that process, helping the consultant or vendor quickly focus on relevant issues and giving the manager a reference point for evaluating proposals.

A Proposed Format for Farm Information Systems Planning Workshops

Most farmers need assistance in identifying their information system needs and in developing a plan for integrating improved information systems into their operations. For many farmers, hiring a consultant to help with these activities is prohibitively expensive, and relying on a vendor whose income depends on sales volume is viewed as risky.

Farms of similar size and enterprise mix are likely to have considerable commonality in their information system needs. This is important for two reasons. First, it is the basis for the market for farm management application software. If needs were not similar, software developers could not sell the same package to many customers. Second, it means that farmers are likely to realize significant benefits and cost savings by working together to identify their information needs.

In this section, we present a proposed format for a series of workshops designed to help farmers identify their information needs. In developing, testing, and evaluating these workshops, we will work toward the accomplishment of the following objectives:

(1) To develop a workable format and set of supporting materials for workshops that can be presented by extension specialists and private consultants.

(2) To evaluate the effectiveness of alternative methods for identifying farmers' information system needs.

(3) To collect data that will enrich our understanding of farmers' information needs and of the factors affecting choices about information system investments.

We propose a series of three one-day workshops on "Identifying Your Management Information Needs." The workshop series is designed for presentation over a three-week period to ten to fifteen farmers with a similar enterprise mix. The overall outline of the workshops parallels the three-stage model of information systems planning proposed by Bowman, Davis, and Wetherbe. Strategic planning is the focus for the first day, organizational information requirements analysis is the focus for the second day, and resource allocation planning is the focus for the third day. A more detailed outline is shown in Figure 3.

The morning of the first day begins with an overview of the workshop and discussion of the participants' objectives in attending. This is followed by a brief presentation on the concept of a business strategy for a farm firm and an exercise in which the participants identify objectives and strategies for their businesses following the format in Figure 1. This is done individually, but this exercise is followed up by a group discussion directed toward identification of similarities and differences in strategies. The morning ends with an assessment of managerial style using results from a standard instrument such as the Briggs-Meyers test, which participants would complete prior to the workshop.

Attention shifts to developing an information system strategy in the afternoon of the first day. MIS objectives are identified by each participant, following the format in the left-hand column of Figure 2. Next, participants identify strengths and weaknesses of their current information systems, noting these in the right-hand column of their organizational strategy worksheets. After a group discussion to compare MIS strengths, weaknesses, and objectives, the afternoon ends with a presentation on the implications emerging hardware and software technologies have for farm information systems. Participants leave on the first day with the assignment of revising their organizational and MIS strategy statements.

The morning of the second day begins with a review of the participants' revised strategy statements. Attention then shifts to an exercise designed to elicit critical success factors for production and marketing in the participants' major enterprise. The morning ends with software demonstrations directed toward giving participants an understanding of the range of features offered in commercial packages.

The afternoon of the second day follows a similar format. It begins with an exercise in which participants identify critical success factors for financial management in their businesses. This is followed with software and service bureau demonstrations. At the end of the afternoon, participants begin work on their assignment of developing information requirements lists for production, marketing, and financial management.

The third day begins with a review of the information requirements lists developed by the participants. Discussion is directed toward identifying similarities and differences. This is followed by a short review on the content of a long range information system plan and an exercise in which participants identify priorities for hardware, software, and training investments. The afternoon of the third day begins with a presentation on choosing a vendor, and the workshop ends with an exercise and group discussion focused on the identification of initial steps toward finalization and implementation of the participants' information system plans.

Copies of exercise worksheets and assignments will be collected for each participant. Group discussions will also be taped. This will provide a rich data set on manager characteristics, management strategies, and information needs. These data will supplement findings from broader surveys of farmers. They will also provide valuable new insights on the effectiveness of alternative information requirements assessment strategies and on the effect of group discussion on perceived information needs.

Identifying Your Management Information Needs

Day 1: Strategic Planning and Your Information Needs

Morning
* Workshop Overview
* The Concept of an Overall Business Strategy
* Objectives and Strategies for Your Farm Business
* Assessing Your Management Style

Afternoon
* Objectives for Your Information System
* Strengths and Weaknesses of Your Current Information System
* What's Possible? Trends in Computer Hardware and Software

Assignment: Revise firm and information system strategy statements.

Day 2: Information Needs for Key Management Activities

Morning
* Review of Firm and Information System Strategy Statements
* Critical Success Factors for Production and Marketing
* Production and Marketing Software Demonstrations

Afternoon
* Critical Success Factors for Financial Management
* Accounting Alternatives: Software and Service Demonstrations

Assignment: Develop a list of information requirements for production, marketing, and financial management in your firm.

Day 3: Developing a Long Range Plan for Your Information System

Morning
* Review of Production, Marketing, and Financial Information Requirements
* The Content of a Long Range Information System Plan
* Hardware, Software, and Training Investment Priorities

Afternoon
* Choosing a Vendor
* Identifying First Steps Toward Implementation of Your Information System Plan

Figure 3. Proposed Outline for Information Systems Planning Workshops

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FARM MANAGEMENT INFORMATION SYSTEMS PLANNING AND DEVELOPMENT IN THE NETHERLANDS

Vinus Zachariasse*

Introduction

The main activity of a manager is decision making. Decision making usually happens in an uncertain environment, which implies imperfect knowledge; i.e., a lack of information about actual and future states. As better information is provided, uncertainty is reduced. So, it can be stated that information is the key element in the decision making process.

Providing information, i.e., communication and processing of information for planning and control, is an important function of the new information technology (IT). Therefore, bringing decision making and IT applications together can make a significant contribution to managerial success.

The Situation Before 1984

In the early 1980s, most experts were convinced that application of the microcomputer with appropriate software would provide considerable opportunities for improvement, not only in process control and farm management but also in the quantification of information for planning and control. Moreover, sharp reductions in hardware prices brought powerful IT equipment within the means of the individual farmer. Nevertheless, the acceptance of IT equipment and services was, and continues to be, rather poor compared with the predictions.

The implementation of electronics and computer science in process management was rather successful in some agricultural branches. In the Netherlands, for example, developments in the automation of the milking parlor, the feeding of concentrates, and climate control in glasshouses can be mentioned. For management purposes, however, the most important handicap for a balanced introduction of IT applications at the individual farm was the poor supply of approved management information systems. Most farmers were waiting to see how this development would settle down. Another major, and until now still existing, handicap for implementation of IT at the farm level was the lack of experience in systematic "information processing" out of "collected" data by the individual farmer. Therefore, only very few farm managers were operating complete farm management information systems (FMIS) at that time.

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In the broader agricultural sector, however, agribusiness firms and unions had been using electronic data and information processing for a rather long time and at an increasing rate for their own management. It was clear that IT was going to activate interrelationships between farms and their decision making environment and that some of the larger scaled companies intended to supply the agricultural sector with IT equipment and services. In that respect, a network for data and program transmission would become necessary. At this point, however, the infrastructure for communications between farms, on the one hand, and different institutions at different locations, on the other hand, was not well developed in the Netherlands.

In summer 1982, I had the privilege to join a group visiting the USA to study the implementation of microcomputers in U.S. agriculture. Some of our observations were:

(1) There was a lot of research in this field at the universities.

(2) Some central information processing services were provided by private institutions.

(3) Attempts were being made to register and qualify software at a central institute.

(4) The best software was developed by farm managers themselves.

(5) It was projected that in 1990 about 50 percent of the medium and larger scaled farms in the USA would have their own microcomputer on the farm.

(6) U.S. agriculture was ahead of Western Europe in the development and implementation of IT for farm management applications.

Our report received much attention. Several initiatives were taken in our country, as in the other EC countries, with the UK agriculture far ahead at that moment. To Dutch agriculture, the most important step in the application of IT came in 1984 when the so-called Information Technology Stimulating Plan (INSP) was launched by the Dutch government.

Activities in the Period 1984-1988

The Information Technology Stimulating Plan (INS Plan) was the initiative of the Ministries of Education and Sciences and of Economic Affairs. The objective was to promote advanced and appropriate use of computer science in all sectors of the economy to improve their international competitive position. The Minister of Agriculture took the initiative and responsibility for the execution of the INSP-Plan in the agricultural sector. In his Strategic Plan 1984-1988 a major effort for coordination of IT in agriculture was outlined. The major parties to be involved included:

- governmental institutions (ministry, university, research institutes, experimental stations of each branch, advisory service, etc.)

- agribusiness (bankers, bookkeepers, input supplying companies, software developing and distributing firms, etc.), and

- farmers (branch organizations).

The main objective of this plan was the active stimulation of the use of process and management hardware and software at the farm level. Applications for management support were to receive particular attention. The INS Plan also addressed agricultural research, education, and advisory services.

Software At Farm Level; Some Preliminary Remarks

Before computers can be used effectively at the farm level, it is essential to ask "What does a farm manager need for better decision making?" The answer is simple: better, that is, up-to-date and continual, management information. Rational decision making follows a cycle built up from several steps:

- problem recognition
- observation of the decision environment
- analysis of alternatives
- decision
- implementation
- control and evaluation

It is evident that particularly in the first three steps, which comprise the planning process, and in the last step, control and evaluation, information is essential. Therefore, management information systems have to be focused on these activities in the decision making process if they are to provide effective support for the farm manager.

A management information system must provide a well designed structure of data base(s), modular (sub)models, and a user-friendly user-machine interface. Therefore, one of the main tasks in the INS Plan was to develop the basic structures of a general overall design of a farm management information system. This task had to be executed by a new institution formed by the farmers themselves.

As a first step in the Strategic Plan of the INS Plan, the organizations of farmers and horticulturists set up five so-called branch organizations:

- dairy (TAURUS)
- pigs (SIVA)
- poultry (SIPLU)
- horticulture (SITU)
- arable crops (SIVAK)

The main task of the branch organizations was to initiate, to coordinate, and to manage the development of management information systems in order to ensure the availability of uniform and coherent software for each major farm type. Most activities of the branch organizations became effective in 1985. The following practical starting points were formulated:

- information technology is the new production factor
- stimulate the use now
- approach from farm level
- develop a growth path for implementation at the farm
- stimulate demand for IT
- coordinate development per branch
- engage research, advisory service, and education
- involve trade, industry, and services for participation in (demo) projects

In order to avoid divergent developments in the different branches, we also identified a so-called branch crossing element. Farm accounting or bookkeeping was chosen as the branch crossing element in the agricultural INS Plan, and it has been developed in close cooperation between the Union of Cooperative Agricultural Accounting Companies (VLB) and the Agricultural Economics Research Institute (LEI).

To coordinate the five branch organizations, a national central organization (COAL) was formed. The secretariat of COAL is under the direction of the Landbouwschap (Agricultural Board). By taking the accounting or bookkeeping as the binding element, each branch could elaborate its specific field for the more technical details.

The branch organizations started their work by defining basic qualifications for management information systems:

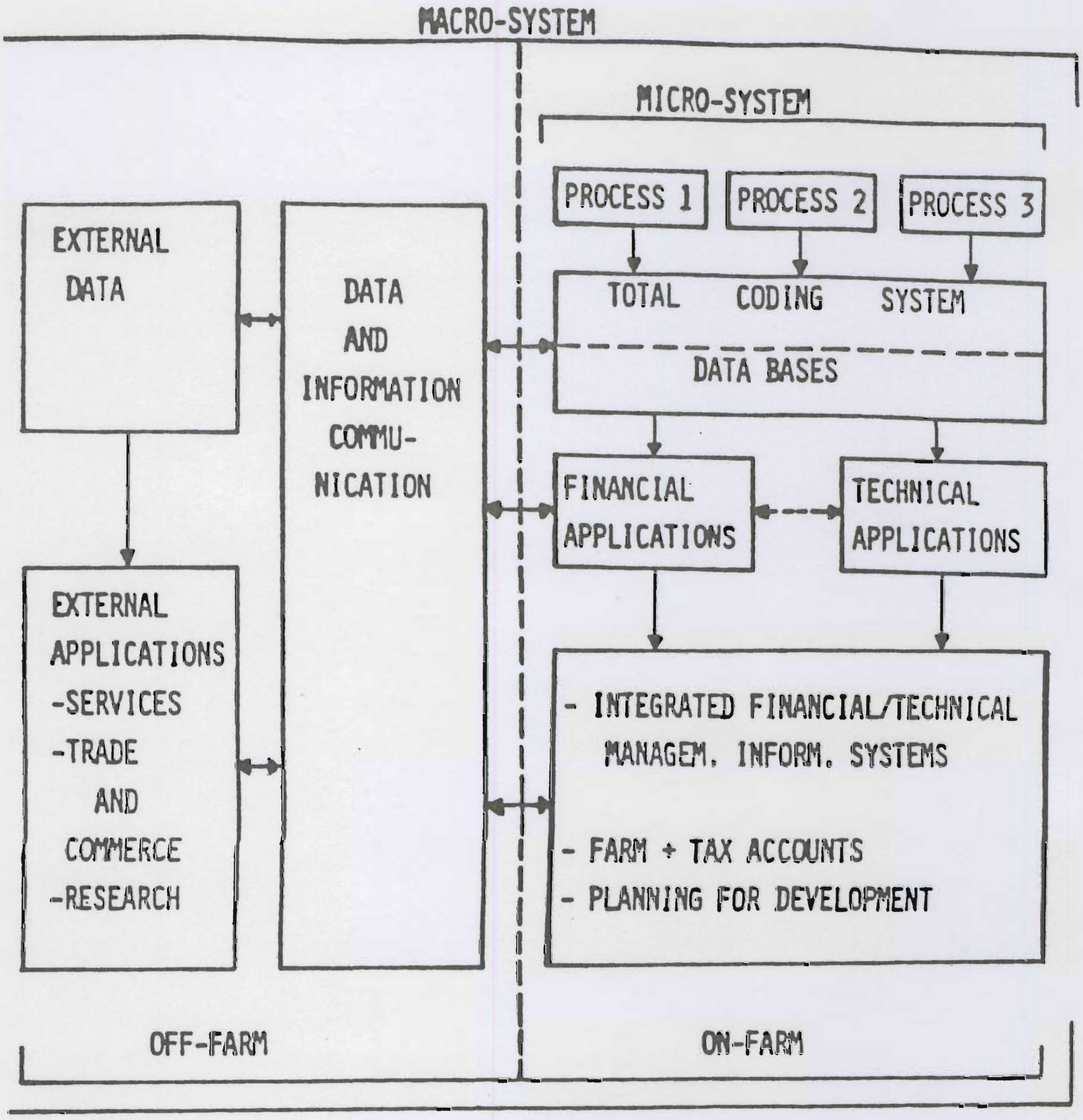
- uniform use of objective definitions, algorithms, coefficients, etc.
- independence of computer brands and software suppliers
- independence of process computers

To meet the first point, a generally accepted concept of an information model for a farm business had to be developed as the basis for an overall design of a farm management information system. To meet the last two points, a normalization and standardization of technical aspects had to be performed.

A General Design of a Farm Management Information System (FMIS)

Looking at the general design of FMIS (Figure 1), consider first the microsystem. The input of technical and financial data, resulting from the different processes, must be registered through a total coding system in well designed databases.

Out of these databases, purely technical as well as purely financial applications can be processed. Technical applications are oriented toward improving technical efficiency of production. Financial applications provide information on margins, cash flow, etc. By



Source: Zachariasse, 1985

Figure 1. Total Management Information System

integrating information from both technical and financial sources, mixed information is provided for the management of the whole farm in applications such as farm and tax accounting and short- and long-term planning.

Information from external or off-farm sources is also required for many decisions. This requires communication. In the future, on-line connections will transmit data and other information along communication networks to and from the farm. Besides transmission of nonprocessed data and information, external applications will be made. These may include the selection of bulls, pesticide recommendations, and breeding selection programs. Besides these "normal" communications, off-farm information processing will be offered to the farmer as a service for value added information. In this way, a total or macro farm management information system will be structured.

It is clear that appropriate systems for communication inside and outside the farm require standardization of definitions, algorithms, and establishment of standards as an essential requirement. This standardization should be at least of national, but preferably of international, order.

As Davis and Olson (1985) state, there are three levels at which information requirements need to be established in order to design and implement computer-based information systems:

(1) The organizational information requirements that are the basis for defining an overall information system structure and for specifying a portfolio of applications and databases.

(2) The requirements of each database, as defined by data models and other specifications.

(3) The detailed information requirements for an application.

In order to formulate the functional specifications for farm management information systems, the branch organizations together with agricultural research institutions and, later on, participants from industry, trading, and servicing companies started the development of global information models for each branch of agriculture. This was a consequence of the method selected for determining the information requirements per farm and per branch, the Information Engineering Method (IE) of James Martin Associates. This method was chosen and accepted by all parties concerned.

The Information Engineering (IE) Methodology is based on four principles. The first principle is that the development of management information systems has to be based on a solid and stable foundation (so-called architectures) in order to get mutually consistent systems which use, if necessary, the same data. Priorities in the development of the systems have to be derived from the business strategy. The second principle is that data are a more stable element than the processes and procedures which use the data. The third principle follows from the word "engineering." It is that there are strictly defined steps and (intermediate) products from each step. The fourth principle is that a top-down approach is followed. The process begins at a global starting point. As it progresses, intermediate products become more and more detailed and cover smaller and smaller areas.

Under the first principle, four architectures can be identified:

(1) The information-architecture, which contains a description of the activities or processes (functional hierarchy), the data (entity type or data model) and the mutual relationships.

(2) The system architecture, which contains a description of the information systems and databases and their mutual relationships.

(3) The technical architecture, which contains the technical infrastructure (hardware, communication systems, etc.).

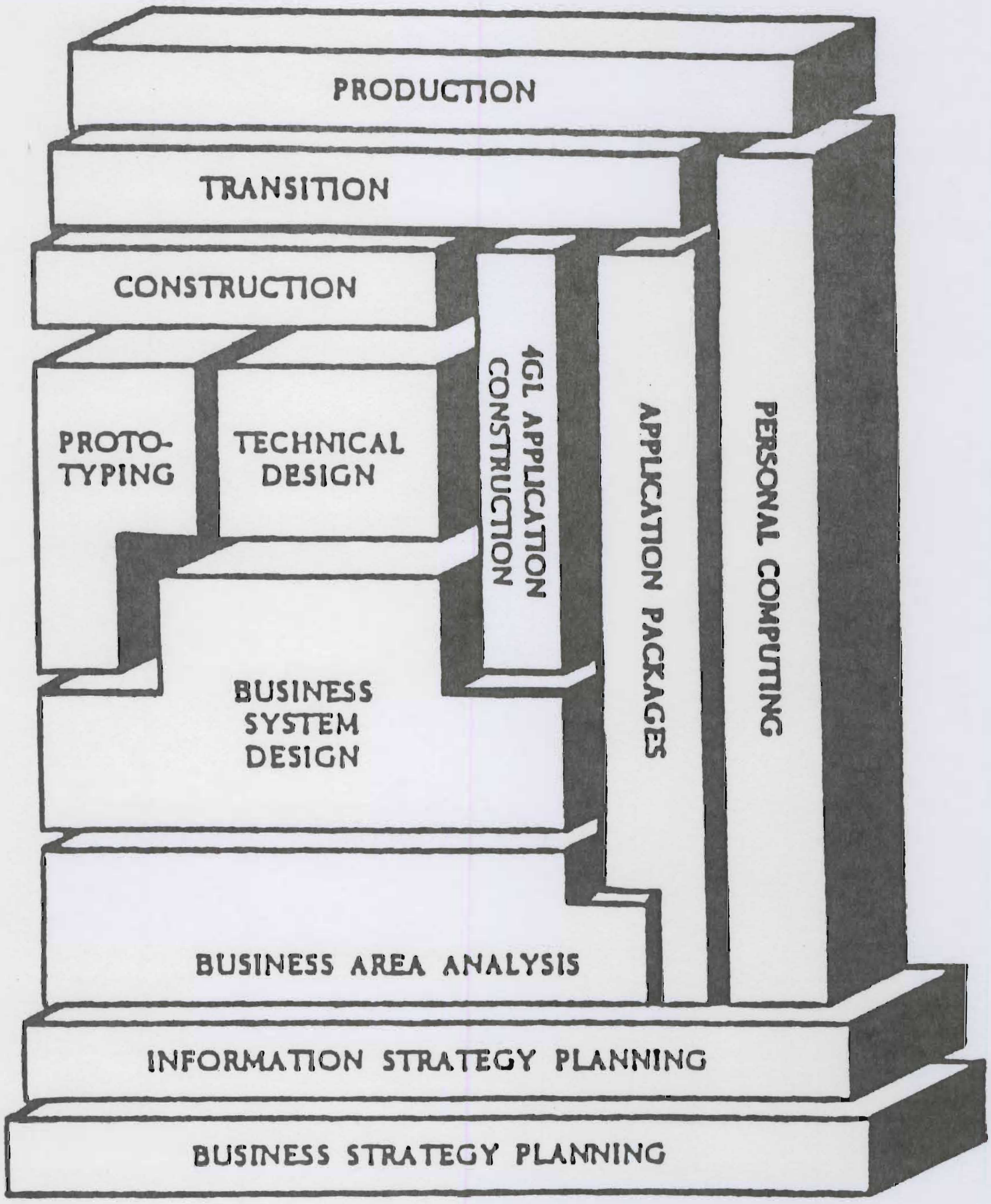
(4) The organizational architecture, which describes the tasks for education, operation, maintenance, development, etc., in the total information-management of a business.

The stages in Information Engineering are (Figure 2):

(0. Business Strategy Planning)

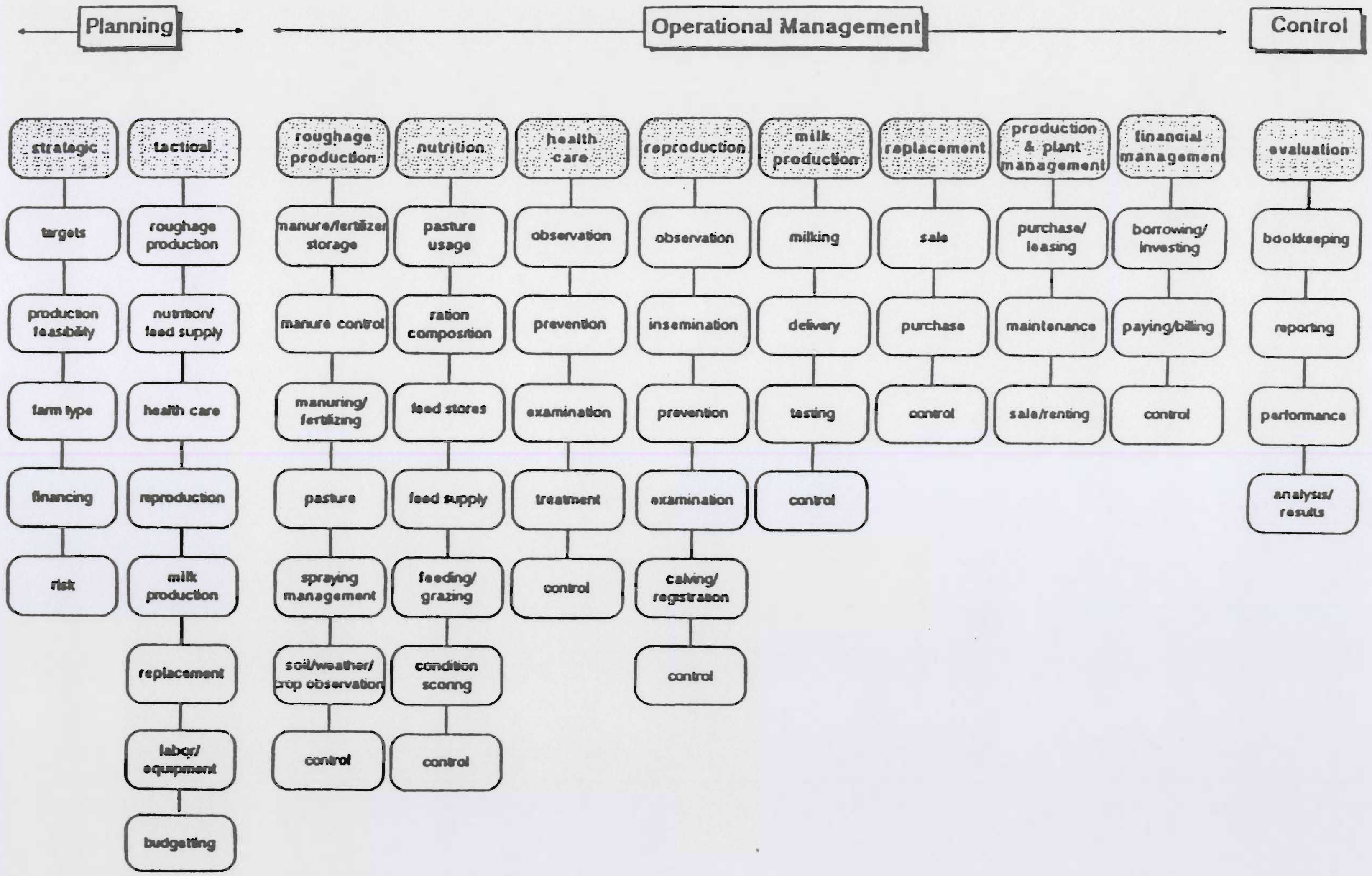
1. Information Strategy Planning (architectures, blueprint)
2. Business Area Analyses (information models)
3. Business System Design (prototyping)
4. Technical Design and Construction (physical data structures and programs)
5. Transition (implementation)
6. Production (maintenance)

An information model is a description of the agricultural operation. The model describes the activities and data which are used to make management decisions. Three levels of decision making are covered by the model: the strategic (longer term), tactical (medium-term), and the operational (very short or executive) levels. The information model contains a so-called process model and a data model. The process model defines activities related to the three basic functions of planning, operation, and control on the farm and the data flows between the processes at the farm level and with organizations outside the farm. This can be shown in a so-called process breakdown diagram. The process breakdown diagram for a dairy farm is shown in Figure 3. The interactions and data flows between functions on the farm and with other external organizations also need to be described for each relevant process. This can be shown in the so-called process-dependence diagrams as illustrated for the subfunction of milk production in Figure 4. In this diagram, the relationships among planning, operation, and control functions for milk production are shown for the short-, medium-, and long-term. In addition to these diagrams, all data and relationships between data created and/or used in each process are defined. This is also done for the calculation rules or algorithms, which are used to transform data into relevant information, for example the algorithms used in calculating a ration for the cows. Together,



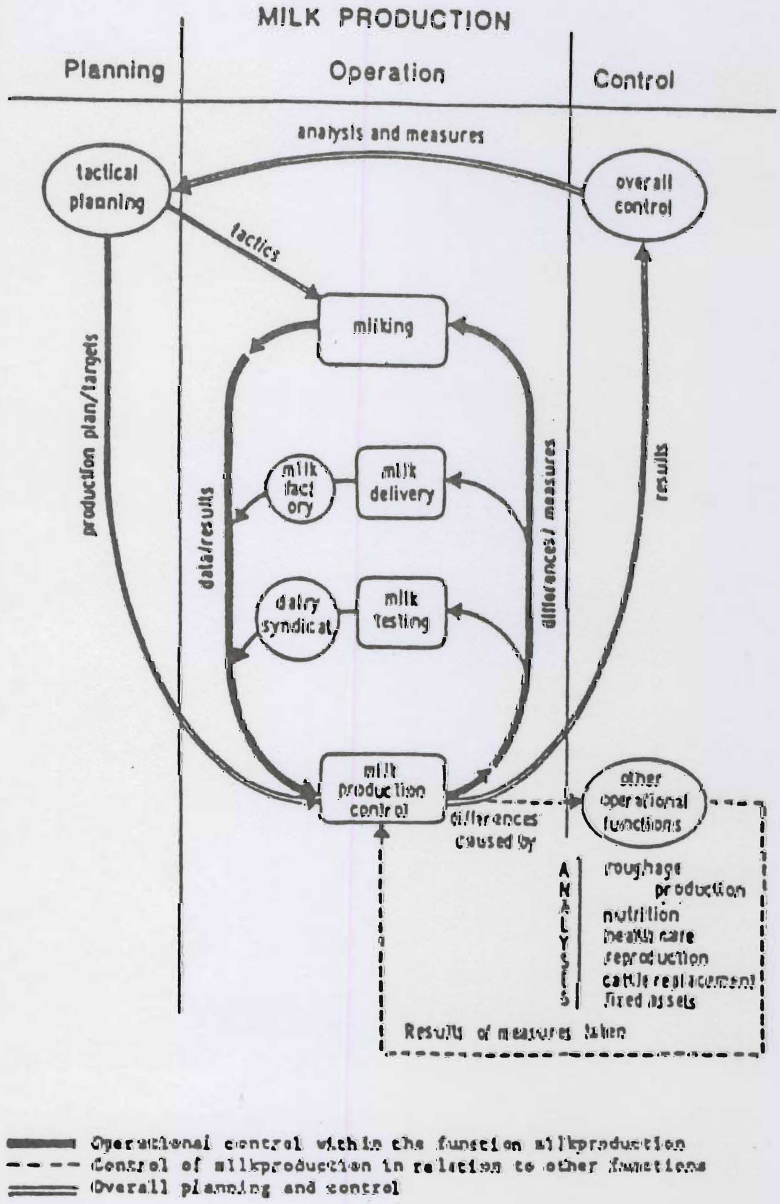
Source: James Martin Assoc., 1984

Figure 2. Stages in Information Engineering



Source: Verheijen et al., 1989

Figure 3. Process Breakdown Diagram for Dairy Farming



Source: Folkerts et al., 1989

Figure 4. Process Dependency Diagram of the Function Milk Production

these diagrams, definitions, and descriptions of processes and their interrelationships make up the process model of a branch of agriculture. The objective in developing such a model is not only to see what relations and data flows there are, but also to determine what is already known and available for implementation in a FMIS and what relations need further research. The process model, therefore, can be regarded as the ideal "blueprint" for the information to be generated by a FMIS and for planning and allocating of research.

The data model is a logical description of the farm data that needs to be retained for the management of the farm. A data model concerns, therefore, the permanent data. On the one hand, it is original data (data measured at the farm and data coming from outside the farm). On the other hand, it also includes data created by one process that are permanently stored for use in other processes (e.g., data used in planning). The data model does not contain derived data. The objective in developing a data model is to define all data and the relationships between data independently of their use. This guarantees unique definitions of the data, especially if they are used for different purposes. The data in the data model are described in terms of entity types (e.g., cow, laborer, financial transaction), attributes, which are characteristics of an entity (identification number, date of birth, etc.), and relationships, which are associations between entities (instances are a specific set of values of entity type or relationships). The relationships between entity types are shown in a entity-relation diagram. The relationships between the process model and the data model can be shown in a matrix with the processes 1,2...N as rows and the entity types 1,2...M as columns. Letters at the intersections of rows and columns in the matrix indicate whether the process creates (indicated by C) or uses (indicated by U) the entity type.

The development of an information model can be divided into two stages. In the first stage the activities and data which are used to make management decisions are described in a global way (global information model). In the second stage (detailed information model) a more detailed elaboration is developed. In the global stage, the farm as a whole is considered, while in the detailed stage groups of strong coherent processes and data (so-called clusters) are defined and worked out separately, usually with the help of technical specialists. It should be made clear that even in the detailed stage of the development of an information model, no computer programs are made. Rather, emphasis is placed on reaching agreement about the content of calculating rules and the definition of data. The development of an information model is done by a working group, directed by a guidance committee and judged by a committee of the potential users.

Before entering the next stage in the development of a new computer program, the system or program design stage, additional agreements must be reached concerning technical specifications for a standardized electronic data exchange protocol and communication techniques between the PC on the farm and external computers and between the management PC and process computers on the farm. This makes it possible to avoid the re-entry of data by hand (e.g., on a dairy farm all relevant milking data are registered in the milking parlor and transmitted automatically to the PC). These agreements on technical specifications are worked out by the branch organizations, together with representatives of the equipment, hardware, and software industry.

Industry, trading, and servicing companies are actively involved in detailing the information models. It is important, maybe even a prerequisite, for all parties to agree on these models as a base for the adjustment of existing software and for the development of a new generation of agricultural software. When the functional (by the information model) and the technical (by the agreements with the industry) specifications are settled, the next stages in the development to new management information systems can be entered with the confidence of getting a good product.

This confidence is based on research regarding the origins of mistakes in the software product cycle. According to findings reported by James Martin Associates (1988) and by Baily (1983):

- 56 percent of mistakes originate from errors in the determination of information requirements, including the functional specifications and design.
- 27 percent of the mistakes originate from errors in the technical design.
- 7 percent of the mistakes originate from errors in programming.
- 10 percent of the mistakes have other causes.

According to the Information Engineering method, the stages that follow the development of an information model are: system design (including prototyping), technical design, construction, transition (including implementation), and the production (including the maintenance). These can be put in a scheme:

process model	→	calculating rules and models
data model	→	data structures and databases
information model	→	information system

In this way, we are trying to guide and to promote the development and implementation of Information Technology at farm level in all branches of agriculture.

Other Instruments in the INS Plan

The branch organizations also use demonstration projects as an instrument for initiating and stimulating FMIS development. In these demo projects, the main aims are to get coherence and standardization of existing IT implementations and activities and to develop new initiatives and activities together with the business "environment" of the farm. Demo projects can include:

- development of farm management information systems for personal computers
- development of software for central processing of information (like systems for farm data registration, farm result comparison, and advisory)
- exploration of relevant external information at locations of industry, trading and servicing companies, and transmission to the farms
- data banks
- communication facilities

The demo projects have also supported the so-called growth path concept; i.e., the gradual shift from postal services for computer use to videotex applications to the use of the individual personal computer-based on similar software in all three stages. In Dutch pigholding, this "ideal" picture of the growth path concept has been in partial operation for several years. At two levels (postal services and personal computers) the same output can be obtained because of the same software, standards, and calculating rules. It is, therefore, possible to move to another stage without problems of interrupting series of data and learning to interpret new output. In this way, the farmer can get used to IT and is more or less protected from wrong investments. At the same time, all data are--by agreement with the farmer--available for further analysis by research institutes, experimental stages, etc.

Moving in this growth path concept to information processing at the farm level, the capacity of the on-farm hardware must allow that:

- software and database management for the day-to-day and for the other frequent decisions can be processed on-farm and

- communication to central off-farm computers is available for infrequently used planning and control/evaluation systems. The same network facilities will be used as a swift communication medium for providing information from central sources to individual farms. This configuration calls for "intelligent terminals" rather than pure stand-alone equipment.

In one of the demo projects for dairy farming, an experiment with data and program transmission along a videotex system has started for a region in the northern part of the Netherlands. It concerns the two-way transmission of data on herdbook, health, A.I., milk control and deliveries, bull selection, cow-calendar, and the financial registration and evaluation of milk returns and fodder costs. Using the normal telephone network, the farmer can communicate by protocol standards through the service computer with the computers of different organizations. This decentralized configuration was chosen in order to avoid high operational costs in the future. For applications in other branches, the videotex medium will be used. For example, in arable farming a regional project in which fertilizer, pesticide, and herbicide recommendations are developed using central data banks and general selection programs has been successful and will be extended to national scale.

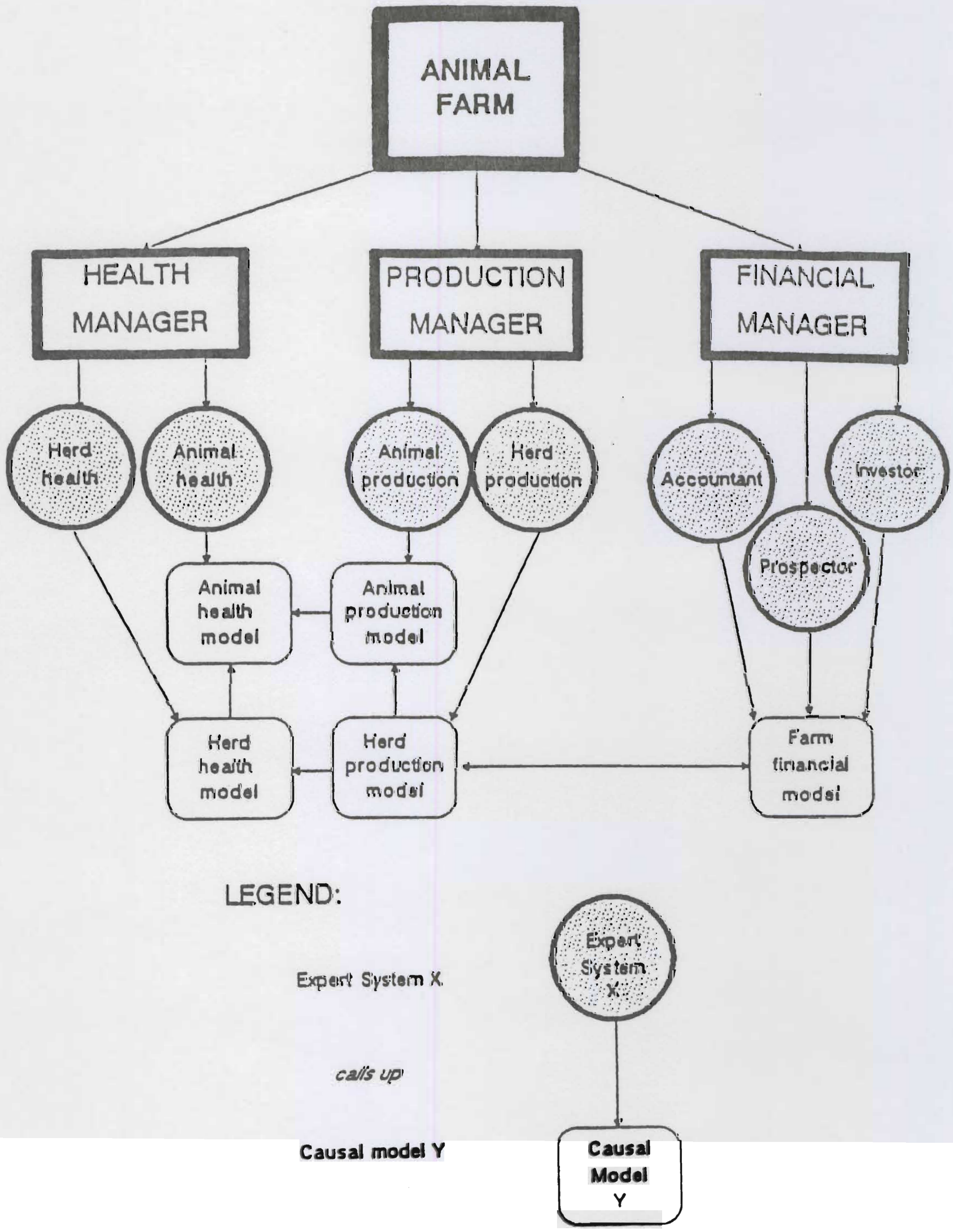
In general, these interactive videotex systems provide an easy to learn and rather cheap introduction to computer use for the individual farmer. Videotex applications are seen, therefore, as an important step in the growth path for farmers towards the use of microcomputers at the farm.

Research on IT fundamentals and applications is an important instrument in the Strategic Plan of the INS Plan for the agricultural sector. In 1987, governmental and private research institutes formulated so-called strategic research projects for the different branches. Most of these research projects did not start on time, or did not started at all, because almost no funds were available at that time. The projects that have been started include: (1) "Dairy farm 2000" with an integrated control system for dairy production (cow-identification, milk yield measurement and recording, sensors for measuring temperature and electronic conductivity of the milk and weight and activity of the cow, automatic feeding and robotized milking) and (2) "Tact-systems," a project for the development of tactical planning systems for use on a microcomputer in dairy farming and in pig breeding. The latter project is mainly executed by the Wageningen Agricultural University (departments of Farm Management and of Animal Breeding) and the Agricultural Economics Research Institute (LEI). Another large project, called "Animal Farm," is still in preparation. This project will be set up to develop an intelligent knowledge-based computer system for integrated management in animal husbandry (Figure 5). Separate versions of Animal Farm will be developed for dairy farming, pig breeding, and pig fattening. Each version will be made up of three second generation expert systems. This means that a rule-base and a causal model will be developed for the Health Manager, the Production Manager, and the Financial Manager. The Financial Manager will use an accounting system and a financial model of the farm to show the past and expected future financial performance of the farm. It will also give advice on investment and borrowing decisions. The project will be executed in cooperation by the Faculty of Veterinary Science of Utrecht, The Rotterdam School of Management of the Erasmus University Rotterdam, the Department of Farm Management of Wageningen Agricultural University and the Agricultural Economics Research Institute. For the methodological aspects of the project, there is a close cooperation with the Carnegie-Mellon University.

All these research projects use, more or less intensively, the information models of the relevant branches, which have proven to be excellent bases for project design.

Other Institutions in the INS Plan

In 1986 the companies supplying IT products and services to the agricultural sector founded, with some governmental subsidy under the INS Plan, the so-called Agrarica Platform. The main aim of this Platform is to strive for a sound market of high quality IT products and services in agriculture by furthering cooperation between the members and acting as a discussion partner with external parties like branch organizations, the government, the central Farmers Organization, etc. This Platform has had a rather slow start because of factors such as mutual competition, the small scale of most of the companies, and difficulty in defining the Platform's position relative to the branch organizations.



Source: Brand and Brée, 1986

Figure 5. Components of "Animal Farm"

Another newly formed institution is a union of users of FMIS in dairy farming. Its aim is to further the development of user-friendly, standardized and certified software and the exchange of experiences among its members.

The governmental Extension Service and educational institutions have also played a role in the preparation of the INS Plan for the agricultural sector. This role has not been as dominant and important as might have been expected. This may be due to a reorganization of the Extension Service and its transition towards a private institution and to a lack of funds and adequately educated staff members.

State of the Art: Evaluation of the INS Plan Period 1984-1988

The 1984-1988 INS Plan for the agricultural sector in the Netherlands appears to have been too ambitious to meet all its aims. The period of five years was too short to implement management information systems which had to be developed from scratch under the supervision of the newly established branch organizations. Nevertheless, most of the officials involved are satisfied with the results.

a. Implementation of IT Applications at the Farms

Between 1986 and 1988, there was a rapid growth in the number of management information systems run on microcomputers on the farm (Table 1).

Table 1. Estimation of the number of micro-computers (including management systems)

	number of spec. farms (x 1000)	1986	1987	1988
dairy farming	42.2	60	150	400
pig farming	7.8	160	400	700
poultry farming	2.0	20	75	150
arable farming	13.9	60	185	260
horticulture	10.2	100	400	1000
		400	1210	2510

As indicated by the figures in Table 2, many more farms entered the growth path by using programs for farm management or for specific subfunctions of farm management provided central service institutions. The situation in 1988 was:

Table 2. Participants in centralized farm management services in 1988

	number of participants
dairy farming	
milk-feed program	8,000
bull selection program	7,800
technical-financial registration program	3,000
pig farming	
management breeding	3,500
technical-financial registration pig breeding	5,000
management pig fattening (new)	100
arable farming	
crop protection wheat	500
crop growing advice sugar beets	500
horticulture (glasshouse)	
farm result comparison	1,400

Many existing IT products and services have not yet implemented the standards of the information models. There is a tendency among suppliers, partly forced by the users, to convert their programs accordingly. In addition, significant improvements are needed in user-machine interfaces. For branch organizations and the union of users, this is a point of action at the moment.

The communication services and media, such as videotex and electronic mail, promoted in the demo projects are gaining more and more interest of farmers and suppliers. Nearly 600 farmers are involved in the demo projects (100 in dairy farming, 230 in arable farming, and 250 in horticulture). Another 1,000 farmers are involved in private projects of supplying companies. In particular, electronic mail is increasing in popularity among farmers for exchanging ideas, advertizing for buying and selling, etc., Expectations are that most of the actual regional projects will be extended to a national level.

Software at Farm Level: General Remarks and Developments. A first general remark regarding software at the farm level is that the adaptability to IT techniques and procedures differs across branches of agriculture and depends largely on the ability to measure, to check, and to correct the production process of that branch in the short-term. The better the progress of the production process can be predicted, the more frequently it can be measured, and the more it allows corrections, the more likely successful farm management information and control systems are to be developed. Dairy farming is particularly well suited for these purposes, as the results are measured each day for each cow and a deviation from the expected yield will activate the farmer to check the cow, the feed composition, etc. Open air crops in arable and vegetable farming are less well suited for short-term control. After sowing and planting, little can be done to manipulate the production process. Between dairy and arable farming, and ranked in order of suitability, are: pig breeding, glasshouse horticulture, and then egg producing and pig and poultry fattening. The progress until now in development of management information systems for these different branches shows a clear and not surprising relationship to this rank in suitability.

A second remark regarding software at the farm level is that a promising future belongs to those management information systems which pay attention to the planning functions by providing budgeted or even optimized targets or forecasts of expected results at each stage in the production processes as well as in the whole farm operation. By providing targets or forecasts, such systems give the farm manager orientation points which have to be achieved in order to reach further goals. In this way, practicing a rational self-criticism, one of basic features of a good manager, can be done better.

In the past, farm accounting has not become very popular among farmers. The main cause can be found in the failure of farm accounts in providing targets or forecasts. Therefore, the integration in farm management information systems of historical records, as is done in farm accounting, and targeting or forecasting will provide the farm manager with more useful information.

A third remark concerns the amount of time the farm manager can and/or wants to spend using a farm management information system. It is evident that those who pay little attention to information processing can expect little from it. In dairy farming in the Netherlands, however, it appears that time spent on a management information system can yield a high remuneration. In similar groups of modern dairy farms with about 140 cows per farm, the group with an improved management information system had annual incomes, on average, about 15,000 USD higher that the farms <u>without</u> such information. The farms with the system, which focuses on the feed-milk relationship, had better results on this particular relationship. In the medium-term, one of the most important advantages is that they use frequent feed requirement projections to discover feed shortages before the market does. In the short-term they notice deviations from the target of milk yield immediately. In a recent research project of the Agricultural Economics Research Institute, it appeared that the farmers using this management information system have a special interest in tactical planning systems. The argument is that planning over a period of 2 to 3 months gives time to take corrective measures in order to prevent problems in that timeframe. The demo project "Tactsystems" tries to cover this information requirement.

This raises again the issue of process control; that is, the control of the technical performance of activities on the farm. In an effective control system, the unit of control should be as small as possible and unambiguously defined. Here, again, dairy farming is in a favored position, since the individual cow provides the basis of a good control system. Based on cow-identification by means of a responder, a so-called closed loop control system can be developed. This means that at several points a cow's behavior and performance can be measured, the observed data can be compared to the expected values and, if necessary, corrective measures can be taken. To make an integrated control system for dairy production, besides the cow-identifier, equipment is needed for milk-yield measurement and recording, and sensors are needed for measuring the temperature and electric conductivity of the milk and the weight and activity of the cow. Data from these measurements makes automatic daily production control per cow and automatic adjusted (concentrate) feeding possible. Temperature of the milk and activity of the cow provide data for health and heat detection, while data on the electric conductivity of the milk enable the farmer to detect mastitis at an early stage.

By modeling the whole system of cow performance in such a way, the operational or day-to-day decisions of the farmer can be reduced substantially. There is a shift to the concept of management by exception, with the control system providing so-called attention lists of cows to be checked and/or treated. Since every cow is different, the control system must be adapted for individual performance. In such a way, the dynamic production process can be controlled electronically. On basis of the control system, the farmer can also prepare better for more strategic or medium and longer term decisions like selection or breeding, culling, etc.

The next step will be the automation or robotization of the milking activity. Experiments have shown that cows are likely to be milked more often that the usual two times per day with such a system. In one experiment, cows offered themselves 5.4 times per day at the combined feeding and milking box and--because of rational intervals--were being milked four times per day. As a result, the behavior of the cows was very quiet, and milk yield increased by about 20 percent per cow per day. This control system is now available on an experimental basis. In the Netherlands, the Institute for Mechanization, Labour and Buildings at Wageningen is making fast progress in integrating it in an operational control system, in close cooperation with the agricultural equipment industry. These results have encouraged efforts to design similar process control systems for other types of husbandry and arable farming as well. The development of appropriate sensors has to be stressed in this respect.

So, on total, developments in the hardware for production process control will lead to substantial adjustments in the production process itself, particularly in housing and equipment facilities and, consequently, in labor and management requirements. It is not an overstatement to say that it will lead to quite new concepts of farming.

One of the important issues in this development is the integration of process control systems with farm management information system. This is an important issue in the demo projects in the INS Plan. In dairy farming the interface developed by the branch organization is now generally accepted. This can be regarded as an important breakthrough.

Let us consider such a management system which has been developed in our Institute over the past decade (Figure 6). We see about the same basic structures as in our general design. The technical side of the farm operation is the part to right and the financial part to the left. We have three databases, each fed with on-farm and off-farm data. For each important part of the dairy farm, a simulation subsystem supports planning not only for the whole year but also for each three month period. For milk production, the use of concentrates and herd control targets are given per two weeks and per day. So for technical performance, a closed loop control system has been developed.

The same can be said about the financial part of the farm operation. By comparing planned with actual results, a closed loop control or a feedback system on the financial performance can be operated.

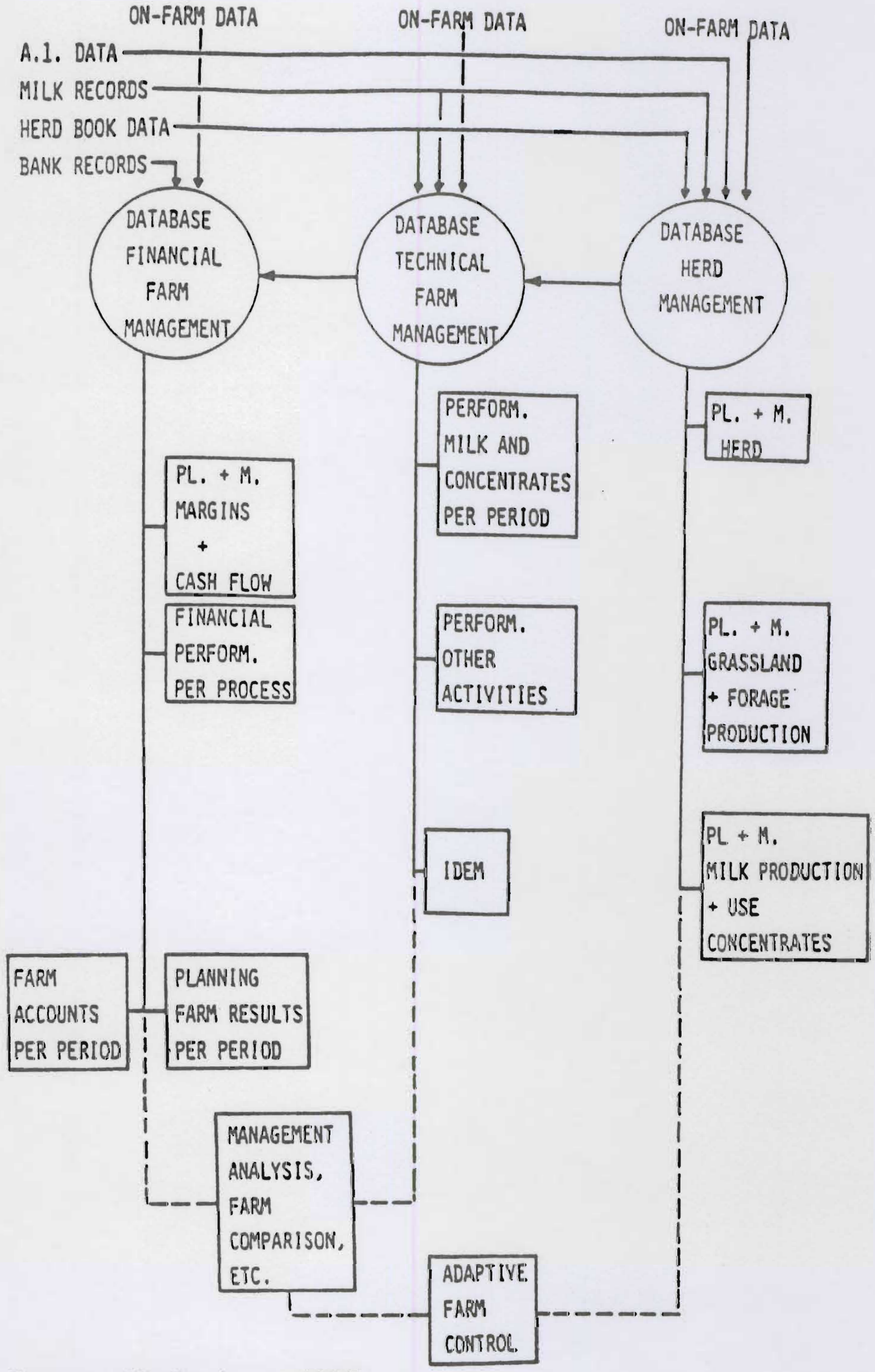
As previously noted, planning is supported by a simulation model rather than an optimization model. Plans are based on key data provided by the farmer. By analyzing farm results and by comparing them to results of other farms or to external standards, the farmer can diagnose the strengths and weaknesses of the operation. After taking corrective measures, the farmer can revise the performance targets. In this way, a so-called adaptive control system for a dairy farm has been constructed.

This management information and control system is developed for a central computer configuration. The dairy farmers who use this system, which is operated on our Institute computer, are enthusiastic about it. Transfer of the system to accounting companies did not succeed very well, however, mainly because they lacked technical know-how on dairy husbandry and because they are not used to planning, since record keeping is the main feature of their job until now.

At present, the whole system is converted for use on a microcomputer in an on-farm configuration. Interfaces are under development for connection to systems, such as a herd management system and an accounting system. This will provide the required data input automatically. We expect much interest for operating this system in such a way, particularly since, as noted earlier, the group using this system has, on average, achieved annual incomes 15,000 USD per farm higher those realized on comparable farms without such information.

In general, it can be said that to cover the annual costs of farm management information system without process control on larger scaled farms, about 1 percent higher gross returns per animal or per hectare of arable land are needed. In our group of farms, we found, on average, 7.5 percent higher net results, so I think this kind of system will pay.

Integration of process control systems and this management information system is one of our main objectives in the near future. Such integrated systems will be more costly, requiring an increase in gross returns of perhaps 5 percent. They seem to pay as well, since it may be expected that results will improve by more than 7.5 percent.



Source: Zachariasse, 1985

Figure 6. Farm Management Information System for Dairy Farms

b. Infrastructure of Branch Organizations

The infrastructure developed under the INS Plan for the agricultural sector has proven to be an efficient and effective one. The five branch organizations and their coordinating COAL have been and are the driving force for most of activities. Because of this success, additional funds are available for the period 1989-1991, and these organizations are invited to make plans for the longer term. Because of their successful role so far, the branch organizations have got permission to broaden their mission to the complete production column (not only the primary sector) and play the role of change agent in encouraging cooperation of people and institutions (like education and extension) involved, including the software firms. Until the end of 1988, the branch organizations had received some 3 million USD as subsidy. An equal amount has been make available for the period 1989-1991. Also, the Agrarica Platform of software producers and supplying companies is getting a better grip on its work and development.

c. Information Models

The information models for dairy farming, glasshouse horticulture, and open air crops (arable farming) are almost finished, as is the branch crossing information model on the financial administrative aspects. Also the model for pig farming will be completed this year. Poultry farming and forestry have completed the global information model and are now starting work on the detailed model. The global model has also been completed for three other small branches. The models for dairy farming and the branch crossing element accounting are much more detailed than those for glasshouse horticulture and open air crops. There is a general tendency not to continue with detailing as such, but to combine it with specific projects as part of the general aim to proceed now to practical IT applications. Additional work appears to be necessary to standardize some of the technical aspects across the branch models (for example, climate in glasshouse horticulture and pig farming). As stated before, the information models are being used more and more for conversion of existing and the developing new IT products. The Information Engineering Method of James Martin Associates is accepted as a common language and framework. In total, the development of the models has been subsidized for about 1.5 million USD. Total costs (including staff of branch organizations and research institutes) are estimated at about 3 million USD. The maintenance, further detailing and promotion of information models has already been organized for the next few years in order to assure the follow-up.

d. Demo Projects

There are 20 demo projects in execution. Others are in preparation. The aim of the demo projects in stimulating the implementation of IT implications is embodied in the criteria: (1) central position of the farm, (2) cooperation and participation of relevant parties like industry, trading and servicing companies and research, education and extension, and (3) coherence with the other INS Plan instruments like information models and other research projects. So far, the demo projects have been efficient and effective instruments for achieving concrete results, and they will be promoted and supported in future. At the end of 1988, in total, 5.5 million USD had been used to subsidize the demo projects. Another 7.0 million USD is available for subsidy.

Development in the Environment of the Farm. As is apparent from the demo projects, developments in the environment of the farm are important for the introduction of IT in agriculture. I will comment briefly on issues concerning supply, training, education, and advisory.

At this stage of development, it is not clear who will supply the agricultural sector with IT hardware and software. In addition to a lot of small enterprises, mostly consisting of one or two people, we see growing interest by an increasing number of the larger-scaled companies in agribusiness for entering the IT market.

The hesitation of larger scaled agribusiness companies in entering the IT market segment is remarkable on the one hand, but understandable on the other hand. It is remarkable because the IT market segment offers the opportunity for a substantial increase in turnover and profit. It is understandable because entering this market segment requires high investments and high costs of organizational adjustments.

Concerning the implementation of IT at the farm level, the supply to and integration in the farm operation of production process control equipment does not present serious difficulty because it is rather similar to other equipment. The supply to and integration in the farm operation of hardware, software, and/or services for farm management information systems, however, will require a major effort by all parties concerned because of the quite different features of these products and services. The growth path concept, as discussed before, from central to on-farm systems requires a "farmer-oriented way of thinking" in the design of farm management information systems. Processing of similar designed programs off-farm and on-farm guarantees a gradual and flexible transition.

Research-based, farmer-oriented, and modularly structured farm management information systems seem to be most appropriate. Prior to marketing, the completeness and reliability of the relations and algorithms in the programs should be tested by independent organizations, like universities and scientific institutes. Other tests should be made by practical farmers. On our study-tour in the USA in 1982, we found that the best programs were those which were developed or modified by farmers themselves. Therefore in the INS Plan in our country, user-panels are an essential part of the Plan and the branch organizations will try to develop quality-certification procedures for hardware and software.

It is my opinion that IT for day-to-day decisions, which are mainly based on on-farm data, has to be operated on-farm. Networking systems will also serve farmers by collecting additional off-farm information as for bull, fertilizer, pesticide selection, etc. They will also be used for medium- or long-term planning for nonfrequent decisions.

But there are more troubles in the environment of the farmer. Because information and services formerly provided by several institutions are being integrated into farm management information systems, both the suppliers and the receivers of information are getting confused about tasks and responsibilities. As a consequence, there may be realignments among the institutions supplying information and services. This will lead to increased competition among them in the near future. For example, banks can easily (and I expect they will) provide accounting services at a reasonable cost. Because accounting has a logical place in an integrated management information system, a milking machine company asked our Institute for a bookkeeping program to sell to their clients. This company had no knowledge of farm accounting. Some shifts like this will occur, but companies that try to offer services outside their expertise must consider the impact on existing facilities and services. In combining their interest in the Agrarica Platform, the suppliers are trying to organize this market segment and to prevent unhealthy competition.

On the other hand, the farmer himself has to be careful when deciding what IT equipment and programs to buy. Buying from a bigger company seems safer than buying from one of the many small firms which come and go on short-term. The same can be said about the companies offering IT services.

In every respect, however, the control of the management information system is the farmer's own responsibility. This privacy aspect should not be violated by any servicing company. Inside information on the financial state of a client will favor the position of the company and may harm the farmer. This privacy aspect is another reason for a modular system, by which the farmer can show and discuss the computer output of one specific aspect of his operations with the external specialist.

Looking at all these aspects, it is not surprising that most farmers see IT as a tricky field. Therefore, for a proper and efficient use of IT equipment and services at their farms, farmers need first of all to be educated and trained. This is a very essential part in the total IT development and adaptation. Looking at the institutions (schools, governmental and private advisory services) which usually provide education and training, we can say that in the case of IT, it is not clear who will take the initiative for training and education.

Let us have a look at the actual state in these institutions. Supplier advisory services are, I think, in the best position at this moment. Their companies are beginning to offer more and more IT equipment and services. Companies look at this market penetration as an investment and hire young and competent advisors to cover this new market segment. In fact, however, they are not used in educating and training farmers as such.

The other institutions, agricultural schools, and governmental advisory services are willing to play their usual role. But in the case of IT introduction, they are facing two important handicaps:

(1) Most of the officials involved in education and advisory first need to be educated and trained themselves. Their lack of training on IT work is still one of the biggest impediments for a more rapid implementation of the microcomputer and associated elements in Dutch agriculture.

(2) The second handicap has been, and to a certain extent still is, the low governmental budgets and reorganization policies, which hamper hiring of new and better educated colleagues in the Extension Service. Over the past few years, more governmental funds have been made available for installing appropriate hardware and software in the schools in order to develop new educational and training programs.

So each of these three groups has its disadvantages. To speed up development, it would be the best if they would cooperate for the benefit of agriculture. For example, IT centers can be established for education and training at schools in order to get an efficient use of hardware and software. In daytime these can be used by youngsters. At other times they can be used for adult education. In some parts of our country this concept is already being practiced. Furthermore, a national center for IT support to agricultural education was founded in 1987. In the INS Plan in our country, still more attention needs to be paid to the aspect of education and training in the use of the computer in agriculture. The need is especially critical because not only the farmers themselves but also their children and their spouses will play an important role in the IT adaptation at farm level.

e. **Evaluation**

At the end of the INS Plan period, 1984-1988, a national evaluation committee of nonagriculturalists reached the following conclusions:

(1) The implementation of management and communication systems in the primary agricultural sector is still at the beginning of the life cycle.

(2) The strong integrated approach on the demand side has created a good starting position for further stimulation of IT implementation in the future.

The commission made the following recommendations:

(1) The stimulating policy should be continued with more attention given to concrete projects and results.

(2) Extra attention should be given to joint research by agricultural and IT specialists.

(3) Projects which cover the complete product column (so-called product chain approach) should be initiated.

These conclusions appear to be widely accepted, and they will be addressed in the formulation of the post INS Plan. The original INS Plan period may be seen as a time of investment. A foundation has been established for a successful continuation in the years ahead. With the help of a subsidy of about 20 million USD and estimated total costs of about 40 million USD, we have began to design a common structure and a common language for IT implementation in Dutch agriculture.

IT applications will not replace the farmer's decision making. They will not turn bad farmers into good farmers. But every farm manager who is interested and is willing to spend time to get used to and--later on--to use IT in his farm will be served by IT in his decision making and may expect a better performance and better farm results. In the end, this is the basic idea behind the joint efforts undertaken by farmers, governmental institutions, and private companies in our country.

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INFORMATION SYSTEMS, DESIGNS AND STRATEGIES: THE IMPORTANCE OF DATABASE, MODELBASE, AND USER INTERFACE STANDARDS

Stephen B. Harsh*

This paper has two main goals. The first is to review some of the past, existing, and proposed standards that have been used in the computer industry which will have a bearing on agricultural information systems. Where appropriate, the advantages and disadvantages of the various standards will be discussed. This review should provide guidance to this regional research committee (NC-191) if it should choose to propose additional standards or guidelines.

The second goal of this paper is to draw attention to some issues that might be addressed by this regional research project. The list of issues identified is not exhaustive. However, it should serve as a starting point for discussion.

Factors Influencing Standards

As Figure 1 illustrates, the first factor that must be taken into account is the hardware system itself. Obviously, software developed for an IBM-PC computer will be different than that developed for an Apple Mackintosh computer. These two computers use different microprocessor chips, display devices, and hardware related user interface.

The difference between these two machines is further compounded by the operating systems employed. The operating systems will influence the procedures used to develop database and application programs. For example, the structure of the files on the Mackintosh (how it is stored on a disk, maximum size of files allowed, number of files that can be opened, etc.) will be different than for another hardware/operating system platform. Also, the operating system will influence how a software developer accesses and controls the display screen, peripheral devices, and other features of the overall computer system.

At the next higher level are the programming languages. Some computer systems offer a wide variety of higher level languages such as FORTRAN, C, COBOL, LISP, and so forth. However, for other operating systems the array of languages available may be more limited. Likewise, the language must be implemented within the constraints of the hardware/operating system platform. For example, a LISP language implemented on a workstation will have a higher level of graphic resolution than that of a typical IBM-PC computer. Thus, these languages need to be adapted to the different hardware/operating system platforms.

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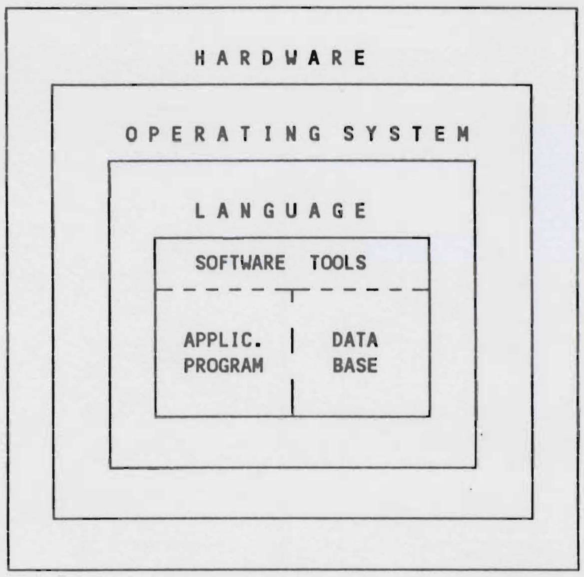

Figure 1. Factors Influencing the Development of Application Programs and Databases

Another factor that influences the design of application programs and databases is whether software tools are used in the development process. These tools make the development of software simpler. However, they are often specialized in functions and are not available for other languages and platforms.

The development of application programs and databases is strongly influenced by hardware, operating systems, languages, and software tools. These factors will have a major impact on possible proposals of standards by the regional research committee. Even though Figure 1 implies complexity, standards have emerged at various levels. What are some of these standards and what success have they had?

Hardware

Even though hardware is often very unique, standards do exist. If a mainframe manufacturer desires to bid on a government contract, it is often necessary for the manufacturer to offer an IBM compatible data channel--a specified standard--for the peripheral devices. There are also standards related to the buses of the more common microcomputer architectures. The MCA, the AT-BUS, and the EISA are three examples of standards at the microcomputer hardware level. There are also several standards as it relates to interfacing input/output devices. The pin configuration for certain serial connections (RS-232) is commonly defined. The same is true for the parallel interface.

Operating Systems

In earlier times, standards that related to operating systems were predominately defined by the individual computer manufacturer. Computer manufacturers generally developed and supported their own unique operating system. However, through time, there have emerged operating systems that are capable of being implemented on a wide array of hardware systems. One of the first to gain widespread popularity and acceptance is the UNIX system. The UNIX system was originally developed by AT&T for a Digital Equipment Corporation computer. It was designed with the intent that the operating system could easily be modified and fine-tuned to other hardware systems. Today, UNIX is installed on computers of different sizes, types, and brands.

In a similar vein, the MS-DOS operating system developed for IBM compatible computers is a standard operating system. If carefully designed, programs developed to run on a microcomputer of a particular manufacturer should also run on a different manufacturer's machines if both use the MS-DOS operating system.

Even though these are generally accepted as "standard" operating systems, there are definite differences within these two examples. For example, there is UNIX 5 which was developed by AT&T. The University of California, Berkeley, has taken the UNIX operating system and made some modifications. Therefore, there are AT&T and Berkeley versions of UNIX. Although they are highly compatible, differences do exist. In some cases, software developed to run on the Berkeley system will not run under the AT&T system and vice versa.

Likewise with DOS, there are some minor differences as well. For example, some manufacturers' versions of MS-DOS allow for larger hard disk partition sizes than others. Thus, an application that may demand a very large disk file will run on one machine but not another.

It is also important to point out that there are interactions between the operating system and the hardware. For example, in the MS-DOS environment there are different display boards (e.g., monochrome, CGA, VGA, etc.) that can be used with MS-DOS. Therefore, software requesting a graphics mode that is not compatible with the graphics board installed will result in problems. Software developers need to be aware of this incompatibility and make the appropriate adjustments in the software.

Languages

In the language area, there are numerous examples of standards that are being employed. For example, there are defined standards as to what should be included in a FORTRAN compiler. Similar standards exist for the other languages such as COBOL and PASCAL. However, for the increasingly popular language C, the standards are less defined. Even for languages where there are well established standards, such as FORTRAN, these standards set a minimum level of features. Some compiler developers add extensions beyond the standard in order to differentiate their compiler from competitors. Often these extensions are hardware dependent. Therefore, if one would like to move an application from one platform to another, it may not be possible if the compiler extensions were utilized.

Software Tools

Software developers are making increasing use of software tools. These software tools include screen handlers, windowing systems, database routines, graphic utilities, expert system shells, and hypertext tools. These tools speed the development and simplify the maintenance of software. Each of these tools have been written to provide unique functions and each tool has its own set of standards. Indeed the developers of these products often try to differentiate their tools from those of others. One exception to this pattern is XWINDOWS, a graphics interface implemented on many platforms of the UNIX operating system.

Other Forms of Standards

There are several other examples of standards being used in the computer industry. The character sets used on most computer systems are based on the ANSI ASCII standard. The original standard was confined to 64 characters. Recently there has been an extension to this standard. Today, most IBM compatible microcomputers use a 256 character set. The upper 128 characters are nonstandard.

Another example, is the structured language (SQL) used in many fourth generation database management packages. This standard relates to the structure of the commands provided and database operations performed by the commands. Although there is a standard set of SQL commands presented to the user, the implementation varies greatly from one database package to another. Usually it is not possible for one database management system using SQL to use another system's files and vice versa.

Additional standards include the characteristic of data buss designs for laboratories have been defined by IEEE. Also, there are standards that relate to transferring data files from one computer to another. The file transfer package FTP/IP is one example of a package that been implemented on many different platforms.

As this regional research committee examines the need for standards, it is unlikely that this committee will have a major influence refining the existing standards of the computer industry. Indeed, if the committee develops additional standards and guidelines, it must be aware of standards already defined for the computer industry and not attempt to develop standards that are inconsistent with these standards.

Database, Modelbase, and User Interface Standards

In dealing with this issue, the concepts as presented in the decision support systems literature will be used as a framework for discussion. Sprague and Carlson (p. 2) define decision support systems as "interactive computer-based systems that help decision makers use data and models to solve unstructured problems." The conceptual design of decision support systems as proposed by Sprague and Watson (House, 1983) reflects the basic components of a modern decision support system (see Figure 2). The modelbase, database, and user interfaces are linked by integrated database and modelbase management systems. The integration depicted in this figure strongly suggests the need for standards and guidelines if an information system is to be efficiently and effectively built, maintained, and utilized. Let's examine each of these components to review what standards have been developed and to identify the need for possible future standards.

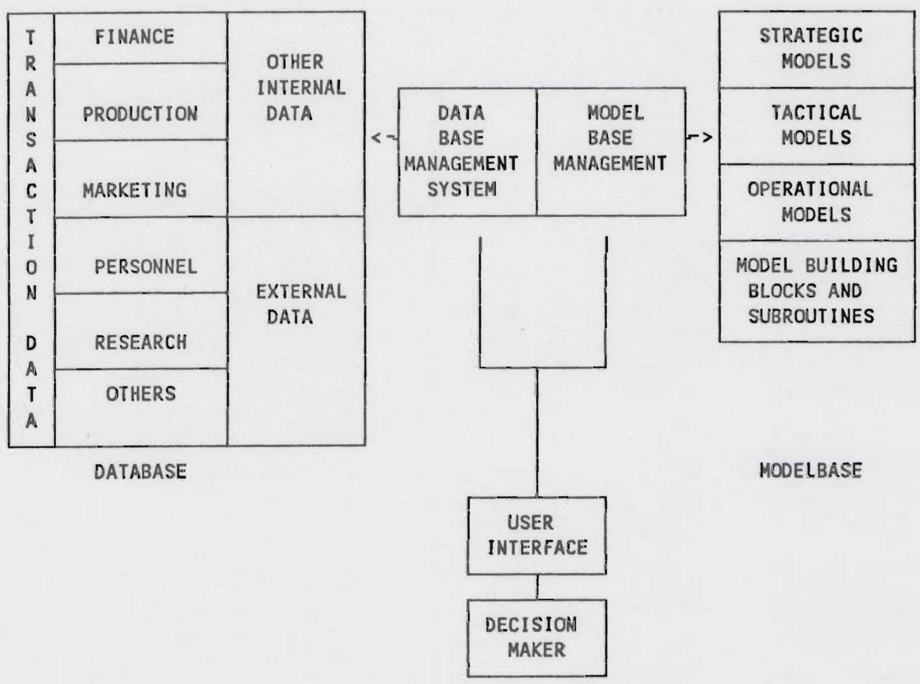

Figure 2. Components of a Modern Decision Support System

Database

There are several levels in which standards can be applied to database components. One approach is to develop a better definition of data elements. For example, the terms (e.g., rate of return) used in agriculture are not commonly understood or agreed upon as to its exact definition. This lack of commonly accepted definitions has caused some problems. There have been attempts to resolve definition problems. For example, the swine industry has developed a set of definitions and formulas for the standard terms used in swine production. The term "pigs weaned per liter" has a standard definition and formula used to calculate this figure. A similar set of standards have also been developed by the Dutch agricultural community for several types of farming operations.

Data can also be defined in terms of entities and their related attributes. This involves defining a data entry (e.g., dairy cow purchase) and its related attributes (e.g., date of purchase, weight at purchase, price paid, source of animal, date of birth, pedigree information, etc.). By using this approach, standards can be developed to define a minimum set of attributes for each data entity. It has been suggested by some that by carefully identifying the particular attributes related to a data entity and developing an extensive coding system related to each attribute, one has a means for standardizing agricultural databases.

Developing and maintaining the list related to each attribute can be a time-consuming and lengthy process. Also, if the code list of the attribute becomes excessively large, its use may be discouraged. A good example of a very detailed attribute list that was developed for farm accounting systems in the mid-1960s. The goal was to allow for easy comparison of financial data from farms in any part of the world. Because of size and complexity of this detailed attribute list, it was rarely employed by those developing computerized accounting systems. Also, for some applications, not all attributes are important for a particular entity (e.g., an accounting system for tax reporting as compared to one for management purposes). Therefore, some databases may contain only a small fraction of all the attributes for a particular entity.

Another strategy that can be used to encourage standardization is the actual development of database structures for different problem situations (e.g., what should be included in a dairy breeding record system). This would involve the actual design of data files, defining of the data fields, and so forth. Such an approach has been used in Europe, particularly in Great Britain. The proposed design structure can then be used as a blueprint by software developers in developing software. With this approach, the databases have similar characteristics implemented across a wide variety of hardware platforms and database systems.

There are a number of other ways in which we can address the database area. Some of the possible options are as follows:

(1) Defining a common set of names to be used for the data files and data fields within a database.

(2) Suggesting a common database system to be used by all developers of agriculture software.

(3) Encouraging the developers of database systems to fully document the structure of their databases such that other software developers can write software what can easily access and use the data contained in the database.

(4) Developing database tools, particularly tools that can be used to manipulate, concentrate, and archive data.

(5) Developing of a set of guidelines for the export of data from databases to other application programs. This is particularly needed for software packages that cannot directly access databases.

(6) Developing a set of standards for distributed databases. As on-farm information systems grow in complexity, the need to upload and download databases in a hierarchical framework will increase in importance. For example, the need to download market information from a central site to the decision maker's own computer will no doubt be needed for some types of marketing models.

(7) Developing a set of standard protocols for data exchange between specialized microprocessors (e.g., milking parlor computers) and a general management computer of the farm.

Standards for Modelbase Systems

The standards that have been developed for the modelbase are less defined and in most cases are unique to each system developed. This does not mean there is not a need for standards. Indeed, the reason for the lack of standards is most likely related to the complexity of developing them. However, possible activities this regional research committee might explore are as follows:

(1) Developing and sharing a common set of algorithms or models among various scientists and software developers. There have been standards developed and used for this type of activity. The International Institute for Applied Systems Analysis in Austria has a set of standards for adding system science algorithms to a shared library. The North Central Computer Institute has a similar set of algorithm guidelines.

(2) Developing a set of guidelines for linking of modules together. As can be observed in Figure 2, the building block approach of linking models is an important part of an information system. UNIX uses a concept of a virtual file to link models. This allows the output of one model to be fed directly into another model. This is one option, are others more appropriate?

(3) To develop procedures to link the modelbase with the database system. Efforts in this area have increased with the availability of database tools (e.g., SQL routines) for higher level languages (e.g., FORTRAN, PASCAL). With these tools, models can easily access and manipulate the databases. However, other interface tools are needed such as the Data Access and Exchange Package (DAX) being developed at Michigan State University.

User Interfaces

User interfaces is an area where we have observed a rapid growth in new technologies and methods for presenting information to the user. This includes the development of windowing environments, user defined function keys, mouse and track ball interfaces, and menu systems. As MacClean points out, growth in user system interface techniques has far exceeded the knowledge level of both the software developers and users in terms of capabilities. Indeed, because of the unique opportunities to use new techniques for developing user interfaces, there is a tendency on the part of software developers to use these techniques as a means to differentiating their product from other conpetitors. There is a great deal of credence placed on "feel and characteristics" of a user interface. The question that needs to be addressed is whether the user interface easily allows the decision maker to obtain the desired knowledge. The user interface will have a predominate role on the success of farm-level information systems.

Even though there are numerous options available for developing user interfaces, there are also guidelines for designing good user interfaces. One example in the field of agriculture is the set of guidelines proposed by the NCR-156 (Expert Systems in Agriculture) committee for constructing expert systems. These guidelines were developed by reviewing guidelines from IBM and others for constructing software. Likewise, a number of textbooks in the area of information systems offer guidelines for constructing user interfaces. Does this committee need to develop a set of user interface guidelines for software beyond those proposed by the expert systems research committee?

Summary

There are numerous standards that currently exist which will influence the development of information systems for agriculture. These standards will provide direction as this regional research committee explores the need for additional standards or guidelines. There are several potential areas which relate to database, modelbase, and user interfaces for suggesting additional standards and guidelines for on-farm information systems. Each potential area must be carefully evaluated with regard to its benefits and cost to the agricultural community before efforts are applied to developing new standards and guidelines.

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