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IMPACT OF MANAGEMENT INFORMATION SYSTEMS ON DAIRY FARM PROFITABILITY

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ABSTRACT

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Seven of 196 New York dairy farms used on-farm computers for accounting in 1984, rising to 23 in 1987. A regression of net farm income per cow on computer use, years computer experience and other variables showed income increasing the first year of computer use, dropping and rising again by year four.

Impact of Management Information Systems on Dairy Farm Profitability

As compared with past decades, more dairy farmers today view information management as important to their business. Farmers' interest in information management is apparent from the number of popular farm press articles on the subject. Farm computer conferences have been held, continuing education classes are available, and user groups have been organized in recent years.

This interest in has been prompted by new computer hardware and software. Powerful computers are available at a reasonable cost. Software is easier to use and is capable of storing more data and doing more useful analysis on it. At the same time, information management concepts are improving. Educators are describing these concepts in terms that are understandable to the general public.

All farmers manage information as they observe crops and livestock, talk to neighbors, and read. A major decision each farmer must make is how much of his/her information management is formalized into written or computerized form. Before computers became available, farmers generally kept written records on only that data required by laws such as tax regulations. Many still limit their data collection to the legal minimum, but much of today's interest in information management results from opportunities to formalize more of the farm's records and analysis, using new computer hardware, software and peripherals. Before the modern computer, many types of data were not written down or analyzed because the benefits of the information were less than the cost of the time required. For some types of information, the computer has reduced this time cost to a level that may now be less than benefits[1].

Davis and Olsen's (1985) popular definition of a management information system (or MIS) will be used to clarify the discussion in this paper: "an [MIS is an] integrated user-machine system for providing information to support the operations, management, analysis, and decision-making functions in an organization. The system utilizes computer hardware and software, manual procedures, models for analysis, planning, control, and decision-making, and a database." This definition illustrates that a successful MIS must include the time and effort of the manager-user. Depending on how much emphasis one places on the terms "computer hardware and software", this definition could imply that a non-computerized record and analysis system is not an MIS. A broader definition of an MIS might encompass formalized systems of manual records and analyses that do not require computers, as well as computerized systems. However, this paper's main point of interest is on the new opportunities and changes that occur when the shift is made to a computer. Therefore, the term MIS will be used in the remainder of this paper to refer to an MIS which includes a computer and software.

Successful use of an MIS necessitates an adequate knowledge base on the part of the user. For example, the manager must understand how to input data for and interpret results from analytic models such as ration balancers. Previously he might have obtained more general information and recommendations from publications, vendors or consultants where the analysis and interpretation was done for him. He must change his work habits to perform new analyses in a timely manner so that decisions can be made and actions taken to keep operations under control.

Purchase of a computer is a major decision for a farmer, not so much because of the investment (less than the cost of a tractor wheel at today's prices) but because it confronts him with decisions about which previously informal MIS components to formalize, requires considerable learning time before information becomes available, and requires changes in ongoing work habits after he does become proficient.

It is difficult for most farmers to visualize the data management capabilities of a computer until they have spent some time trying it out in their own offices. Consequently, the decision to adopt an MIS often is made before he knows very much about the concept of an MIS or about computer hardware and software. The first question he asks is "is the system likely to help me manage more efficiently and profitably?" Experiences of other farmers can provide some indication of whether the answer is likely to be affirmative. Many anecdotal reports have been published about experiences of individuals, but it is unclear whether only the success stories get written up while the failures are ignored. A more comprehensive analysis of a group of computer-using and non-using farms could help answer this question.

Many authors have discussed what to consider when buying a computer and starting on the road to a formalized MIS. The decision to adopt an MIS can be analyzed using standard capital budgeting techniques. Harrison and Williams present one such example format for assessing the potential returns from an adoption. A recent paper by Putler and Zilberman found that size of farming operation, educational level, age, and the ownership of a farm-related nonfarming business significantly influence the probability of computer ownership by California farmers. However, it may be difficult to arrive in advance at estimates of changes in individual income and expense items that are expected to change due to the MIS. Rather than an *a priori* assessment, the purpose of this study was to analyze the actual impact of adoption of an MIS on profitability of a group of adopting New York dairy farms.

Methodology

Detailed profitability data from a group of 196 New York dairy farms was used for the analysis. These farms participated in a farm business summary and analysis program (DFBS) conducted by Cornell University and Cooperative Extension. The farms are thus not a random sample but are generally believed representative of farms with above-average management levels. The farms all participated in DFBS over the four year period, 1984-87. One farm had been using a computer for two years in 1984. By 1987, 23 farms (12 percent) of the group were using on-farm computers as their primary accounting systems. The DFBS farms were all full-time operations with dairy as the primary enterprise. More than 500 dairy farms participate in DFBS annually, but the same farms do not participate each year. This analysis was restricted to the 196 farms that participated in all four years. An earlier study on 335 DFBS farms showed that in 1986, 64 percent of the computer users owned freestall barn facilities compared to 36 percent of the group as a whole (Lazarus and Smith).

DFBS is a unique dataset in that business and financial data, including accrual profitability measures, are included as well as resources used in the business and production levels. Herd size and crop acres are included, and age and education of each of up to four farm operators involved in management of the business. Type of barn and some other technology data items are included.

The primary objective of DFBS is to help farmers improve their management skills through appropriate use of record data and application of modern farm business management decision making techniques. It helps identify strengths and weaknesses of the farm business. Ideally for the purpose of this study, a firm-level production function would be estimated and used to analyze the impact of the MIS input on output levels. However, the DFBS input use data lacks sufficient detail to estimate a firm-level production function, so an alternative approach of comparing trends in net farm income was employed. Data on on-farm computerized accounting systems was used to estimate their impact on profitability.

DFBS data on farmers' use of MIS is limited to the type of accounting system and type of dairy production records used on the farm. Accounting systems are categorized as: account book, mail-in service bureau, or on-farm computer. Dairy records choices are: Dairy Herd Improvement Cooperative (supervisor sampling), owner sampling, other and none (Smith et al.). Interviews of 27 DFBS computer users in 1986 showed that accounting was the most common agricultural use of the computer, with 89 percent of the farms doing accounting on the computer (Jofre-Giraudo et al.) Accordingly, computer use for accounting was used as the measure of MIS adoption in the statistical analysis. Other agricultural uses reported in the interviews were ration balancing (52 percent), dairy herd management (41 percent), telecommunications (26 percent) and crop management (11 percent).

Seven of the 196 farms in this study used computers in 1984. This increased to 11 users in 1985, 17 in 1985 and 23 in 1987. Computer users managed herds about twice as large on average as the non-users. Users also carried about $600 more debt per cow on average. It has often been said that the younger generation may find it easier to learn to work with new technologies such as computers, so age of the farm operators was also analyzed. DFBS includes data on each operator on the farm, and some farms have as many as four operators. Interviews of farms with several operators indicated that younger operators with more education tended to be the individuals actually using the computer, so the farms were analyzed by age of the youngest operator on the farm. Computer users were, on average, four years younger than non-users (Table 1). Seven of the computer using farms managed herds of over 200 cows in 1987, with one over 1,000 cows. Thirteen of the non-users had herds of over 200 cows, with one over 500 (Table 2).

The main hypothesis considered in this study is that after some time for adjustment to the new MIS, profitability of adopting farms will trend upward compared to non-users. Net farm income per cow is the profitability measure used, defined as total accrual receipts minus total accrual expenses divided by cows milked. Expenses include expansion livestock purchases and depreciation as well as operating expenses. Data summarization and exception reporting are expected to be more useful on larger farms where direct observation of individual cows is more difficult, so MIS seems more likely to have a positive impact on profitability of large than small farms.

Large farms are expected to be more profitable than small farms whether or not an MIS is adopted. This is because of economies of size from spreading overhead costs over more producing units and from volume purchase discounts and improved marketing.

The farm firm life cycle theory would suggest that age of the operators affect profitability (Harsh et al.) Very young operators may have a higher level of energy but suffer from inexperience and lack of capital. Younger operators may operate less profitably at the start, then improve as they consolidate resources. Profitability may decline later as operators prepare to exit the business.

Other factors considered are educational level of the operators, debt level and form of business organization. Better educated operators are expected to help the management team on the farm make better decisions and thus operate more profitably. Higher debt levels will clearly hurt profitability as interest costs are subtracted from net farm income while interest on equity is not. Farms with partnership or corporate forms of organization may or may not operate more profitably apart from farm size effects.

<u>The Statistical Analysis</u>

With these hypotheses in mind, the following model was formulated to explain annual observations of net farm income per cow on the farms over the four-year period, 1984-87:

$$NFICOW_{it} = COMPUTER_{it} + EXPERIENCE_{it} + EXPERIENCE_{it}^2 + COWS_{it} + COMPUTERxCOWS_{it} + EXPERIENCExCOWS_{it} + EDUCATION_{it} + AGE_{it} + AGE_{it}^2 + COMPUTERxAGE_{it} + DEBT/COW_{it} + PART_{it} + CORP_{it} + YR85 + YR86 + YR87 + U_{it}$$

where

$NFICOW_{it}$ = net farm income per cow for farm i in year t (t = 1984, 1985, 1986 or 1987),

$COMPUTER_{it}$ = 1 if the farm is using an on-farm computer for the primary accounting system,

$EXPERIENCE_{it}$ = number of years the on-farm computer has been used (1 in the first year that the computer was used for the primary accounting system),

$COWS_{it}$ = average number of cows milked,

$EDUCATION_{it}$ = years of education of the most highly educated operator on the farm (12 = graduated from high school),

AGE_{it} = age of the youngest operator,

$DEBT/COW_{it}$ = total farm debt per cow,

$PART_{it}$ = 1 if a partnership, 0 otherwise,

$CORP_{it}$ = 1 if a corporation, 0 otherwise,

YR85, YR86 and YR87 are dummy variables to capture differences in profitability from year to year due to changes in milk prices and other factors that affected all farms in the group, and U_{it} is the error term. The variable YR85 was set to 1 for observations from 1985 and 0 otherwise, with the same pattern for the other years.

The COMPUTER variable was included to allow for a dichotomous change in net farm income when the computer is first purchased. The EXPERIENCE variables allow for a nonlinear impact on income trend. COWS captures economies of size in the operation with a larger herd. The

COMPUTERxCOWS and EXPERIENCExCOWS terms permit modelling computer impacts that vary by herd size.

It is not clear on conceptual grounds how to model the influences of multiple operators' educational levels and ages on profitability of farms with more than one operator. As far as computer use is concerned, the interviews revealed that typically one operator uses the computer more than the others. The computer user tended to be a younger and more highly educated individual, such as a son or daughter recently graduated from college. For that reason, the highest educational level of any operator and the age of the youngest operator were used in the model. Other analyses were also tried using averages of ages and education of all operators, but the model fit was not as good. The COMPUTERxAGE term was included to see if younger operators in fact do make more productive use of the computer.

As discussed above, two of the farms were considerably larger than the rest of the group. Management practices and information use are likely to be quite different on those farms. Most dairy farms in the Northeast and Midwestern regions of the U.S., the main population for which we wanted to make inferences, are much smaller. These two large farms were excluded from the analysis in order to obtain results applicable to more typical farm sizes. Also, data from one other computer user was deleted because changes on business organization made comparability of the data over the four years questionable. One hundred and ninety three farms, or 772 observations as defined over the four years, were included in the final analysis. This left 4 observations (all from 1987) from farms which had four years of computer experience compared to 23 observations on first-year use (in whichever year the farm first used a computer), 16 second-year, and 7 third-year observations. Deletion of the three farms reduced the statistical significance of some of the coefficients but had little effect on predicted net farm income per cow on the small to medium-sized farms.

It is well known that ordinary least squares estimates of production function parameters from pooled time series-cross section data such as this are subject to bias (see for example Mundlak, 1961 and 1978). To avoid this bias, generalized least squares was employed. A random effects estimator was used in which the error term was decomposed into an individual farm effect and a purely random effect. The RATS statistical package by VAR Econometrics was used for the analysis. The results are shown in Table 3. The Goldfeld-Quandt test for heteroskedasticity was also performed (Maddala). It showed that the data are homoskedastic.

The signs on the COMPUTER and EXPERIENCE^2 coefficients are positive and significant at the five percent level. COMPUTERxCOWS is negative and significant. EXPERIENCExCOWS is positive but not significant, while EXPERIENCE is negative and significant. The COWS coefficient is not significant, but its positive sign indicates that net farm income per cow increases with herd size, indicating that the expected economies of size are present. The COMPUTERxCOWS and EXPERIENCExCOWS coefficients have signs that indicate that smaller farms were more likely to see improvement in the first year of computer use. Larger farms were more likely to see improvement after several years of computer use.

The hypothesis that all of the computer-related variables jointly have a non-zero effect on the dependent variable was also tested. When COMPUTER, EXPERIENCE, EXPERIENCE^2, COMPUTERxCOWS, EXPERIENCExCOWS and COMPUTERxAGE were excluded from the model, the resulting $F_{6,755}$ was a significant 3.01. The nonsignificant EXPERIENCExCOWS and COMPUTERxAGE were negatively correlated with the other variables. Removing these and the other nonsignificant variables from the model decreased the significance of the remaining coefficients. For that reason, all of the variables were left in the model.

Predicted net farm income is $228 per cow without a computer for a 200 cow farm with a 40 year old operator with 14 years of education and $2,000 of debt per cow, with the 1987 dummy set to 1. Income rises to $313 in the first year of computer use. Predicted income per cow then falls below the initial level, to $165 in the second and $199 in the third years. Then it rises to $414 in the fourth year. It seems logical that income may increase in the first year as the newly available data reveals opportunities for improvement. The operators' interest in the new information may flag after the easy changes are made, so income may well plateau for awhile. An alternative specification was also tried, where the six computer-related variables were replaced by four dummies. The first dummy was set to 1 in the first year of computer use, the second was set to 1 in the second year, and so forth. This alternative specification gave essentially the same pattern of predicted net farm income from the first to the fourth year of computer use.

The positive COMPUTERxAGE term suggests that younger farm operators are more likely to make profitable use of a computer. The other coefficients show that apparently partnerships and corporations have done better than sole proprietorships apart from size effects which are captured by the COWS variable. As expected, higher debt levels have a negative impact on income. Finally, the year dummy variables seem to indicate that the farms did progressively better over the period. This was a period when milk prices were dropping but feed and other cost items were also decreasing.

Conclusions and Implications

It appears that farms beginning to use on-farm computers in the 1984-87 time frame have experienced improvements in profitability relative to similar farms that did not adopt the new technology. The percentage of farms using computers is still small, so there appears to be considerable opportunity for industry-wide productivity improvements as other farms follow suit. Not every farm manager will be willing to make the changes in management practices and work habits necessary to produce potentially useful information and to act on it. There were computer-using farms in the sample whose income dropped when the computer was adopted. As with most investments, the returns to computer ownership are uncertain. Despite that, this study provides evidence that an MIS is likely to be a good investment of time and effort, at least for dairy farms of 100 cows or more.

The empirical results presented here are limited by the availability of data on relevant variables. It would be ideal to have information on other input variables, such as soil quality. In addition, tests for misspecification could be carried out to spot potential problems with the specification of the model. Nonetheless, the model stands as an important first step toward an empirical investigation of the profitability impacts of an MIS. While other nonstatistical methods have been used to study the problems of profitability (e.g. Jofre-Giraudo et al.), such case study material has its own limitations, suggesting the need for researchers to make an attempt to quantify the impacts despite constraints of the data. This study then lays the groundwork for the considerable additional investigation needed to explore the profitability effects of computerized information management.

Table 1. Herd sizes and Debt Levels of Farm Computer Users and Non-Users

	Computer Users	Non-Users	All Farms
Number of farms			
1984	7	189	196
1985	11	185	196
1986	17	179	196
1987	23	173	196
Average herd size			
1984	196	88	92
1985	222	90	97
1986	189	93	101
1987	194	93	105
All years	198	91	99
Average farm debt per cow			
1984	$2,778	$1,905	$1,936
1985	2,230	1,869	1,889
1986	2,581	1,796	1,864
1987	2,494	1,726	1,816
All years	$2,504	$1,826	$1,876
Age of youngest operator on the farm			
1984	38	40	40
1985	41	40	40
1986	36	41	41
1987	37	41	41
All years	37	41	40

Table 2. Herd size distributions of computer users and non-users, 1987.

	Computer			
Cows milked	Users		Non-users	
	number	percent	number	percent
Less than 100	7	30	124	71
101-200	9	40	36	21
More than 200	7	30	13	8
All farms	23	100	173	100

Table 3. Generalized least squares model of net farm income per cow explained by computer use and other variables, 193 New York dairy farms, 1984-87.

variable	coefficient	standard error	t
Intercept	287	94.9	3.03
$COMPUTER_t$	902	272	3.32
$EXPERIENCE_t$	-544	183	2.96
$EXPERIENCE_t^2$	90.6	35.8	2.53
$COWS_t$	0.380	0.250	1.52
$COMPUTERxCOWS_t$	-1.85	0.872	2.12
$EXPERIENCExCOWS_t$	0.622	0.413	1.51
$EDUCATION_t$	-8.56	7.23	1.18
AGE_t	5.38	6.38	0.844
AGE_t^2	-0.119	0.076	1.55
$COMPUTERxAGE_t$	-2.95	5.44	0.544
$DEBT/COW_t$	-0.0969	0.0113	8.58
$PART_t$	43.0	34.6	1.24
$CORP_t$	61.3	83.9	0.731
YR85	36.5	21.8	1.67
YR86	65.6	21.9	2.99
YR87	153	22.4	6.82

$\bar{R}^2 = 0.178$ $F_{17,755} = 39.13$

Durbin-Watson 1.94

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Footnote

[1]The term computer will be used in this paper to refer to general purpose microcomputers that can be programmed to perform different tasks, as opposed to special purpose units such as computerized grain feeders.