Determinants of Farm Size and Structure

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EMERGING TECHNOLOGIES AND THEIR IMPACT ON AMERICAN AGRICULTURE: INFORMATION TECHNOLOGIES

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The structure of the agricultural sector, and especially the declining number and increasing size of farms, continues to be a subject of concern in our society. Farm numbers have declined from about 4 million in 1959 to 2.9 million in 1974. At the same time, a dramatic increase in concentration of agricultural production has occurred. The number of farms accounting for one-half of all farm sales has dropped from 205,000 in 1959 to 125,000 in 1974. This has resulted in a bi-modal farm distribution: a small number of large farms accounting for the majority of production while many small farms exist. In 1974, for example, approximately 4 percent of the farms accounted for one-half of all farm sales.

Projections suggest a continuing decline in farm numbers and increasing consolidation of agricultural production. After adjusting for inflation, Lin, Coffman and Penn project a 1.75 percent annual rate of decline in total farm numbers between 1974 and 2000. Although this rate of decline only is about half that for the decades of the 1950s and 1960s, the result still is a dramatic concentration of production. Under their projections, the share of farm receipts for the largest 50,000 farms increases from 31 percent in 1974 to 63 percent by the year 2000. The 1986 report of the Office of Technology Assessment (OTA) projects an even higher 2.19 percent yearly decline in farm numbers, resulting in 1.25 million farms by the year 2000. This OTA projected decrease is relatively greatest in the small and part time categories, a conclusion perhaps resulting from OTA assumptions about differential technology adoption rates across farm size categories.

Several determinants of structural change have been suggested. Tweeten (1984) identifies the major causes as technology, economic growth, and off-farm earnings. Also, farm programs tied to the control of resources as a basis for determining program benefits have created incentives for firm growth as have federal income tax policies which reward investment (Hanson; Davenport, Boehlje and Martin). Technological change generally is viewed as a major determinant of structural change, although dissenters exist. Kislev and Peterson, in an analysis of farm size increases, "explain virtually all of the growth in the machine-labor ratio and in farm size over the 1930-70 period by changes in relative factor prices without reference to 'technological change' or 'economies of scale'" (p. 578).

This paper focuses on the role of technological change as a determinant of agricultural structure. More precisely, the potential impacts of emerging information technologies are explored. To place potential impacts into context, the classical diffusion

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model and the induced innovation hypothesis are explored in the next section. This is followed by a description of emerging information technologies and ways in which these technologies differ from previous technological revolutions in agriculture. Some suggested impacts of information technology on future farm structure are offered. The final section provides empirical evidence about differential adoption rates for information sources for farmers of differing age, education level and other attributes.

Innovation Diffusion Models

In the classical diffusion model, Rogers (1962) models diffusion as a sociologic, three step process: invention, diffusion and structural reorganization. Inventions are defined as ideas perceived as new by an individual. Diffusion is the process by which innovation spreads, essentially through human actions. Diffusion then results in structural reorganization. Five characteristics of innovations influence the length of the diffusion period (Rogers): 1.) relative advantage -- the degree to which an innovation is superior to ideas it supersedes,[1] 2.) compatibility -- the degree to which an innovation is consistent with existing values and past experiences of the adopters, 3.) complexity -- the degree to which an innovation is relatively difficult to understand and use, 4.) divisibility -- the degree to which an innovation may be tried on a limited basis,[2] and 5.) communicability -- the degree to which the results of an innovation may be diffused to others. Of these, relative advantage, complexity and compatibility are the most influential in determining the rate of technology adoption.

Solo is critical of the sociologists' diffusion model, charging that the sociologist has "taken organizational structure as given, and has concentrated his creative inquiry on the variation of individual motivation and behavior and the dynamics of inter-personal relationships as they occur within the organizational frame" (pg. xi). Economists, on the other hand, have been blinded "to those variations in motivation and value and to the patterns of interpersonal-relationship that may well be the crux of the phenomenon of underdevelopment" (Solo, pg. xi.).

Economists have based their models primarily on changing relative costs of factors employed in the production of goods and services. Schumpeter identified innovation as the essential function of the entrepreneur. By his definition, innovation (and the innovator) are quite distinct from invention (and the inventor). "Innovation is possible without anything we should identify as invention and invention does not necessarily induce innovation, but produces of itself . . . no economically relevant effect at all" (Schumpeter, pg. 84). In his Theory of Wages, Hicks is the first to use the term "induced innovation in the context of induced biases of technical change. He argued that changes in factor prices create a bias that causes producers to substitute resources in a fashion to save the relatively more expensive factors. However, as Binswanger observes, "because biases and rates of technical change are determined simultaneously, we prefer to use the term for all theories that are concerned with explaining rate and bias of technical change as endogenous to the economic system" (p 22).

Tweeten (1986) characterizes previous technological change in agriculture as belonging to three distinct revolutions. The first revolution featured the wheel and simple hand tools, irrigation and domestication of plants and animals. "The first revolution lasted for thousands of years and was still underway when the first white settlers came to America" (pg. 1). The second revolution began with the industrial revolution in Britain during the late 18th century. It brought cheap steel, railroads and steam power, the steel plow and a host of animal-drawn implements. The third revolution was primarily mechanical, chemical, and biological. Beginning about 1920, it brought electrification, chemical fertilizers and pesticides, improved plant and animal genetic material and the modern tractor and its compliment of machinery. Embodied in these technologies was a tremendous potential to substitute capital for labor and/or land.

Tweeten (1984) observes that "farming adjustments to technological change have reduced the share of farm output required to pay labor and management costs... [and thus] farm scale had to be expanded to realize any given labor-management return". Furthermore, "due to a slowing in scale-related technological change apparent in the factor share of labor ... technology is projected to require slower growth in farm size in the 1980s and 1990s. However, as in previous decades, technology remains the single largest force causing farm firm growth" (pg. 23).

Viewed as a production relationship, any inward movement of the isoquant represents technical change. Technical change is said to be neutral with respect to a factor when that factor's share of total costs is the same before and after the technical change, given constant factor prices. That is, the ratio of inputs is constant in both the old and new technologies. If the relative usage of factor (i) decreases with the technical change, the change is said to be biased and is i-saving. An increase in the relative use of factor (i) is said to be biased and i-using.

Figure 1 graphically illustrates these relationships. Isoquant I_1 represents an existing frontier technology, showing substitutability of capital and labor at a constant output level. Presuming that individuals A and B are producing the same output, individual A operates an inferior technology because the combination of inputs lies off the efficient isoquant. Individual A is technically inefficient. Individual B is producing with the correct technology, but, B has not chosen the correct set of inputs given prevailing factor prices (indicated by the isocost line AA'). Hence, B is economically (allocative) inefficient.

Isoquants I_2, I_3, and I_4 (each with identical output, Q_0) represent substitution of labor and capital under three new technologies. Technology I_2 represents a neutral technical change. With constant relative factor prices, this technology combines the two inputs, labor and capital, in the same ratio as did the technology (I_1) which it replaced. Technology I_3 is capital-saving. This technology, again with constant relative factor prices, calls for an input combination which employs relatively less capital than did the existing technology. Similarly, technology I_4 is labor-saving. The relative use of labor in the input mix is reduced.

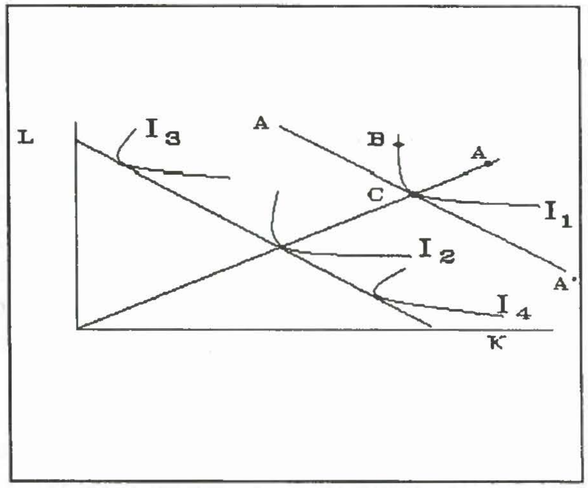

Figure 1. Technical and allocative inefficiencies and technical change.

To assess the relative importance of labor-saving and land-saving technology on labor productivity in U.S. farming, Swanson and Sonka use data on productivity and efficiency (1940-77) for the U.S. farming sector. They separate farm output per unit of labor into its two technological components. Acres per labor unit is used as an index of labor-saving technology, and output per acre as an index of land-saving technologies. Their results indicate a quadrupling of area of land farmed per unit of labor since 1940 but the index of farm output per acre has increased only about one-half as much. They conclude that labor-saving technologies have been more influential during that past half century than land-saving technologies when describing the changing productivity of agriculture.

What are the information technologies?

Information technologies, broadly defined, include all those developments designed to measure, store, retrieve, process and communicate data or information. Its output, information, is then used as an intermediate product in the production relationship.

A consensus definition of information has yet to be reached. Differing concepts are used. Eisgruber suggests that "data are not information ... rather, there are intervening acts of interpretation ... which transform data into information by placing them in a specific problem context to give meaning to a particular decision" (p.901). That is, information is data processed in a form so as to become meaningful to the user, and is of value (real or perceived) in the context of a specific problem situation (McDonough; Davis).

Information can be thought of as an input in the managerial decision process (Debertin et al.). As an input, the farmer will be willing to seek (or purchase) additional information as long as the perceived marginal benefit from using that piece of information exceeds its cost of gathering and processing. And, to the extent that it reduces uncertainty, information acquisition allows a more efficient allocation of other productive inputs at the farm level. The value of a piece of information is tied to potential gains or losses involved in a particular decision. Any message conveys to the decision maker some expectation with respect to its usefulness. This translates into a possibility of improved profit or the avoidance of losses. The gain from information is the difference between expected utility in prior and posterior states of information (Hilton). The value of additional costless information can never make the decision maker worse off, and eventually can make him better off (Chavas and Pope).

The so-called information technologies impact the agricultural sector much differently than previous technologies. And, one might question whether, in fact, they represent true technical change with respect to agricultural production. To facilitate this exploration, let us define the following general production function:

$$Q = f_1(\text{ Land, Labor, Capital, Management })$$

Management includes both the entrepreneurial (risk-bearing) and decision-making functions. Decisions include selection of inputs and technologies. Management can also be viewed in a functional sense:

$$\text{Management} = f_2(\text{ Initial Abilities, Human Capital, Information Flows })$$

Initial ability describes an individual's inherent capability to conceptualize and solve managerial problems. Enhancing these abilities is human capital which can be built through education and experience. Because managers operate in an uncertain environment with imperfect information, information flows impact management by improving a manager's knowledge of the decision parameters or by providing improved estimates of the probability distribution of outcomes. This information allows the manager to make decisions more consistent with his objective function. All three factors influence quality of management by reducing the likelihood that the firm is experiencing technical or allocative inefficiencies.

Figure 2 presents a pictorial view of the linkage between the firm's information system and its production process. Heavy lines show physical flows while thin lines show flows of data and, as denoted, information. Decision variables are those physical inputs into the production process that are within the control of the manager. These include selection of fixed inputs or capital-embodied technologies. There is a mix of market and nonmarket outputs from the process. All of this takes place within an environment (physical, social, economic and political) which is exogenous to the system.

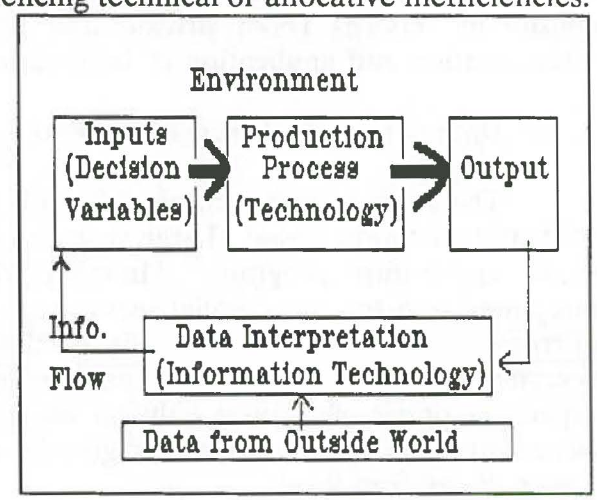

Figure 2 Production process with information feedback loop.

Information technologies primarily facilitate the processing of data into information. As such, they do not modify the physical production process.[3] Instead, information technologies allow better choice from among the decision variables, and thus more efficient allocation of inputs.

The separation of information and production technologies is useful when considering changes in agricultural structure that are likely to occur with developments in information technologies. Using this dichotomy, information technologies have few characteristics common with other technologies introduced in the agricultural sector. They usually do not change the production process, but instead allow more control of existing production technologies. Referring back to figure 1, information is useful in helping individual A find the appropriate production technology and individual B find the correct mix of inputs given prevailing market prices. Information, however, does not necessarily shift the efficient frontier.

Emerging information technologies

There are a number of information technologies of relevance to farm firms. These include technologies differing widely in use. We have categorized these technologies into four groups based on their application. Although this categorization implies separability, these technologies may be applied as a system.

1. Communications technologies

The new communications technologies allow for more rapid and reliable transfer of information. Included here are both 1.) hardware developments such as fiber optic cables, satellite communication and computer hardware, and 2.) information dissemination networks. The latter includes computerized information delivery systems, satellite relay of information (broadcasts or signals targeted to individual subscribers), and the network of consultant services (both private and public) that have developed to facilitate the interpretation and application of information.

2. Data processing/storage/retrieval technologies

The modern information collection/storage/retrieval/processing technologies are primarily computer based. Large scale integration of circuits is largely a bi-product of the space exploration program. However, these basic developments have been quickly integrated into the commercial sector and are primarily responsible for the advent of the microcomputer. Within a decade of their introduction, microcomputer systems have become extremely capable, possessing processing speeds and primary and secondary storage capacities previously found only on expensive mainframe computers. Because explicit ownership costs have been reduced greatly, microcomputers allow distribution of processing power to the firm level.

Although hardware developments are necessary for firm level computer processing systems, a more important component of this technology is embodied in computer software. The earliest computers were programmed with hard-wired circuits programmable only by engineers. This was followed by early generations of programming languages which could be constructed only by individuals well educated in the use of such languages. Although more flexible than hard-wired circuits, application programs developed with these languages typically required substantial development costs. Programs were written for very specific tasks.

Computer languages have now developed to what is typically described as the fourth and fifth generations. These are more highly structured languages, typically are more "macro" in nature -- meaning that the computer does more of the tasks of memory, input, and output management given a few simple instructions by the user -- and frequently are presented via a graphic interface. This has resulted in a computer environment operable by individuals with little training. Furthermore, much of this development has occurred for microcomputer technology.

A well known software package illustrating the impacts of these developments is Lotus Development Corporation's spreadsheet software. The program is presented in a format that is intuitively easy to comprehend. Data and programming logic are intermixed rather than separated as in the earlier generation languages. Relationships among data are represented spatially rather than in sequential program code. The program is self documenting. And, results can be presented numerically or graphically via a number of preprogrammed, flexible graphing routines. Most commands are presented via a menu system. The program is general in application: Individuals from any field can use this software to develop specific applications for decision support with small development investments. For instance, development of an enterprise budget can be accomplished in the software almost as quickly as it can be done on paper. And, once completed, it can be solved repeatedly with differing parameters almost instantly.

3. Artificial intelligence / expert systems

The fifth generation of languages, as usually defined, include artificial intelligence (AI) and expert systems. AI remains in the development stage. The concept of artificial intelligence is a simple one. Computers are programmed to process data and draw conclusions in the same manner as do human decision makers. However, the process of developing such software systems has proven difficult. The primary difficulty has been modelling the human thought process. Humans use elaborate intuition and qualitative judgments when making decisions. On the other hand, computer languages developed to date have required that all alternatives be sorted through using logical comparisons (IF-THEN-ELSE structures). As a result, complex problems must be modelled individually. Each decision requires a specific computer program. And the development costs typically outweigh the benefits of computerizing the solution unless the decision and its parameters are identical for a large number of decision makers or the decision is repeated frequently. AI programming, if successful, will allow complex decisions to be modelled with much less development cost and thus will allow automation of a larger set of a firm's decisions.

Although AI exists only as a future promise, another technique, termed "expert systems", already has demonstrated its value. An expert system is a computer based algorithm which allows a problem to be addressed in much the same way that a human expert would seek a solution. The primary power of an expert system is informal reasoning based on extensive knowledge obtained from human experts. In most expert systems, this knowledge is included in the form of hundreds of logical comparisons or rules of thumb. Most decisions can be cast as a search for a path from an initial state to a desired final state with many restrictions constraining the set of alternatives which are viable. As Lenat has observed, "most interesting problems also share the characteristic that they are too complex to be solved by random search because the number of choices increases exponentially as one proceeds from the first intersection or decision point". The expert's rules constrain the search of decision alternatives by guiding the program toward the most likely solutions. Lenat concludes "the essence of artificial intelligence in expert systems to find . . . ways (similar to those of the human expert) for the computer to limit the search for solutions". The expert system program may also be written so that it may learn from past experience in problem solving.

To date, there have been few successful uses of expert systems, and most of these lie outside the domain of agriculture. However, one may see from analogy of these successes that there is fertile ground for similar applications in the agricultural sciences. For instance, one successful application is in the area of medical diagnostics. Expert systems have been developed to diagnose bacterial blood infections. (Lenat (p. 207) describes such a system, called MYCIN, developed at Stanford University). The objectives of the program are to determine the particular infection and to recommend a course of treatment. Input into the program is in the form of illness symptoms and results of lab tests. As the program proceeds toward a solution, additional lab tests may be requested. The program has been demonstrated capable of performing on par with human practitioners.

4. Automated systems

Automated systems represent true technical change and include robotics, process control and automated data collection. Much like the machine revolution, these technologies embody new ways of substituting capital for labor. Robotics and process control involve the merging of computer technologies with electromechanical control devices. Process control requires either real-time computer processing or stand-alone microprocessors. The development of low-cost microcomputers opens the door for economically feasible process control for small business. Modern dairy technologies provide an example of process control in agriculture. Technology exists to allow automatic identification and feeding of individual cows via magnetic identification tags and automated feed dispensers. The quantity of milk produced can be sensed automatically by a device in the milking pipeline, and recorded on computer media along with cow identification number. This data can be processed, allowing input from the herd manager, to adjust the ration fed to the cow in subsequent feeding periods. Datta et al. reported research results of an on-line milk monitoring system for milk conductivity, milk temperature and milk yield. Using a statistic calculated from milk conductivity, a method of mastitis detection was established whereby three consecutive observations of milk conductivity above a critical value would be indicative of mastitis. Application of such a system would allow the manager useful information for herd health and feeding decisions without substantial time commitments for data collection and processing.

Robotics are currently being used in a variety of ways in industry. The complexity of these applications vary substantially, ranging from relatively simple process control activities (e.g., inserting bolts in an assembly line process) to systems which incorporate artificial intelligence concepts to allow decision making within the process (e.g., making a weld if the positioning of the parts is correct and then evaluating the quality of the weld). Although robotics have been used primarily for assembly processes, there is fertile ground for development of agricultural applications of robotic processes. Conceptually, automatic systems could be linked with artificial intelligence/expert systems to provide adaptive learning processes. As of yet, few advances have been made in this area.

Emerging Information Technologies as a Determinant of Farm Structure

Even though the information technologies differ substantially from previous farm technologies in the way they impact the firm, structural implications for agriculture may exist. Literature on diffusion of innovations indicates that early adopters often are large farmers who eagerly seek new knowledge, and as such, highly value information (Rogers, 1983). Projections of the OTA study suggest that a dramatic trend toward larger and fewer farm firms will be exacerbated with the emerging biological and information technologies. The OTA trend estimates were based on assumed differential adoption rates by farmers of differing sizes: For instance, expectations that 70 percent of the largest firms will adopt some of these technologies by the year 2000 versus adoption rates of 40 and 10 percent for moderate and small sized farms, respectively (Phillips). Certainly, this assumed differential in adoption rates are very important in the trends suggested. Other authors (Tweeten, 1986; Lin, Coffman, Penn) have estimated the rate of growth in farm size to be only about half as large as found in the OTA study.

There are a number of reasons to argue that adoption of information technologies will progress differently than previous agricultural innovations. With the mechanical revolution, the ability to substitute capital for relatively expensive labor was embodied in machines requiring relatively large durable capital outlays that needed to be spread over a large output to achieve low cost per unit of outputs. This created an incentive to expand farm size.[4] However, many of the information technologies require only relatively small fixed explicit outlays. Ownership costs are minor. And, many of the information service networks are priced on a variable cost basis. This argues for a relatively small incentive for business expansion.

On the other hand, there may be substantial implicit costs that make total costs of adoption large and thus favor adoption by larger firms. Information technologies often are complex. Unlike the tractor which was simple to operate and could quickly be mastered, the computer and its complement of software may require lengthy periods for the typical manager to gain facility with this technology. Furthermore, larger firms can better afford specialized labor in the form of a computer operator or information specialist.

Many of the information technologies are management intensive. Information is not employed directly as an input in the production process as are fertilizer, seed and fuel, but rather as an intermediate input which is useful if its interpretation allows other inputs to be regulated in an economically more efficient manner. Thus, information is applied through a feedback loop mechanism. The quality of management, therefore, influences how the firm will respond to a given piece of information. Thus, if management quality and innovativeness are correlated with any attribute of farm structure, we may see differential adoption and structural change with respect to this attribute. In support of this observation, a recent study by Putler and Zilberman concludes that "results indicate a trend in the adoption patterns of computer technology toward large farms and well-educated farm operators" (p. 800).

Information technologies will be varied in their effect of the firm. Some will be labor saving. For instance, the use of computers for data collection and processing and robotics. Other technologies may be output increasing. That is, more accurate and timely information can mean better regulation of the production process and greater output. Other information technologies may be both labor using and output increasing. History has demonstrated labor-saving technologies to be more influential on structure in the U.S. than has been land-saving technology. This may suggest an important role for robotics and process control in the future of agriculture.

As with a large number of technological advances in the post industrial era, basic development occurs in sectors other than agriculture. Innovation or application of the technology in agriculture follows these basic developments. Because most computer and communications hardware is identical for applications by farmers or any small business person, development of this technology can proceed more quickly than could previous mechanical technologies. Similarly, the emerging computer software is general in application. It too will be developed largely outside the agricultural sector. Innovative farmers will search out that software that is useful in decision support just as will innovative entrepreneurs in main street businesses.

There are a number of public agencies that may serve to facilitate development of information dissemination networks and computer software. For instance, the National Aeronautic and Space Administration (NASA) recently has help to create a number of institutes across the nation. These Centers for the Commercial Development of Space are designed to foster partnerships between public researchers and commercial market participants, to identify possible applications of remotely sensed data from space and related information technologies. The net effect may be to speed the development of an infrastructure for dissemination of agricultural information.

Information Use on Ohio Commercial Farms

A recent study in Ohio may prove useful at this point. This study examined information use of 1,800 commercial farm in Ohio. Although this research did not explicitly consider the adoption of new information technologies, it does provide insights into how farm structure may influence adoption of information technology. Two pieces of evidence from this study are presented: 1.) farmers perceptions of information usefulness, and 2.) adoption of micro-computer technology.

I. Farmers Perceptions of information usefulness

Farmers perceptions of the usefulness of various information sources are presented in table 1. Although perceptions of each information source do not relate directly to adoption of information technologies, they indirectly provide indicates of potential differences in adoption of information technologies. If usefulness perceptions vary, it also is likely that information technology will vary because information is an output of both the firm's information system and sources outside the farm.

To analyze usefulness, farmers were asked to rank information from 23 information sources as "very useful", "useful", "not useful", or "do not receive". Based on these usefulness rankings, a mean usefulness score for each information source was constructed. Responses of "very useful", "useful", and "not useful" respectively were assigned weights of 2, 1, and 0. These weights simply represent an ordinal measure of each farmer's perception of the usefulness of each source. Because they are ordinal measures, an information source receiving a weight of 2 should not be interpreted as being twice as useful as a source receiving a weight of 1. The weighted responses were averaged across farmers, excluding those who responded that they "do not receive" information from the source. Excluding "do not receive" responses implies that these farmers are not in a position to judge the usefulness of the information source. Although this interpretation may not be strictly true, including "do not receive" responses would presume more than is known.

Usefulness scores for a grain farmer sub-set of the commercial farmer sample is shown in table 1. These farms had at least 200 tillable acres and no significant livestock enterprises. Only grain farmers are included to control for differences in information use by farms having different enterprises (signification variations exist). Significant differences in usefulness scores exists between farms having less than 600 crop acres and those farms having more than 600 acres. Farms with over 600 crop acres gave higher usefulness scores to information from the cooperative extension service, commercial newsletters, marketing consulting services, and brokerage firms. Lower scores were given to television reports and local newspapers.

When examining significant differences several trends are notable. Larger farmers seem to prefer more marketing information (marketing consulting services and brokerage firms). Also, larger farms tend to prefer more specific information, as indicated by the higher scores for commercial newsletters, marketing consulting services, and brokerage firms, and the lower scores for television reports and local newspapers. This may suggest that larger farmers will adopt information technologies yielding marketing information and more specific information faster than smaller farms.

Significant differences exists along farmer characteristics such as age and education, as illustrated in table 1. These may be just as important as farm structure characteristics in explaining information use, and thus technology adoption. Note that the presented analyzes are simple univariate tests, thereby not allowing comparisons of jointness between variables. Multivariate techniques, such as logit analysis, yield similar results. These results suggest that farmer characteristics should also be included when analyzing information technology adoption.

2. Adoption of micro-computer technology

Adoption of micro-computer technology provides a more direct measure of information technology adoption. Table 2 shows ownership of computers by 1.) grain farms -- at least 200 acres and no significant livestock enterprises, 2.) dairy farms -- at least 20 cows and no other significant livestock enterprise, and 2) mixed livestock farms -- farms having significant livestock enterprises other than dairy.

Differences exist in computer adoption and use between differing farm types and farm sizes. Ownership of computers differs between mixed livestock farm and grain and dairy farms. More significant differences exists between computer uses. 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. Ownership of computers varies by farm size. Larger farm tend to own more computers, as indicated by the significant larger percentages for grain farm over 600 acres and dairy farms having over 60 cows.

Summary

There are a number of information technologies with promise for agriculture. Because these developments have applicability in a number of sectors of the economy, they probably will develop much more quickly than previous agricultural technologies. With the exception of robotics and process control, these technologies are not likely to be highly capital intensive. Thus, innovative farmers will quickly try these technologies.

The information technologies differ substantially from previous farm technologies. Again, with the exception of robotics and process control, the information technologies impact the management process rather than the physical production process. Imaginative, high quality managers will be able to use these systems to increase the quantity or quality of their decision analyses. The manager's effective "capacity" can be increased. Differential adoption rates are likely. But, these differences may be more closely correlated with quality of management than with farm size or other structural dimension.

More empirical research is needed in this area. Preliminary research at Ohio demonstrates that significant differences exist among farmers in preference for information. However, we do not yet understand the demand for information well enough to explain well these differences. Certainly, there is room in a project such as NC-181 for this research.

Endnotes

1. Rogers indicates that relative advantage is often expressed in economic profitability but may be measured in other ways. Thus, the influence of relative factor prices as an inducement to technological change is reflected to some degree in the classical diffusion model.

2. Although not precisely identical, this characteristic relates closely to the lumpiness of durable capital-embodied technologies and impact of excess capacity on the average total cost structure of firms. The classical diffusion model recognizes the importance of evaluation and trial periods in the adoption decision process, and suggests that such indivisibilities restrict the innovator's ability to experiment with innovations.

3. Exceptions are robotics and process control technologies. These represent new processes by which labor and capital can be combined in the process, and thus represent new production technologies.

4. Furthermore, as income tax legislation became a more important determinant of farm investment decisions during the decades of the 1960s and 1970s, this trend was exacerbated. Farmers often bought large, new machinery in order to reduce taxes. But, they often were left with excess machine capacity. This offered the opportunity to reduce costs and expand profits by further expanding the size of business.

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Table 1. Mean Usefulness Scores by Farm Characteristics for Commercial Grain Farms, 1987.

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
Local Market Reports	1.32	1	1.33	1	1.31	2	1.34	1	1.35	1	1.22	2
General Farm Magazines	1.29	2	1.28	2	1.35	1	1.23	3	1.30	2	1.26	1
Radio Reports	1.23	3	1.14	7	1.16	6	1.24	2	1.25	3	0.97	10 c/
Agricultural Newspapers	1.17	4	1.20	6	1.22	5	1.15	4	1.20	4	1.10	5
Specialized Farm Magazines	1.14	5	1.22	5	1.29	3	1.03	8 c/	1.18	5	1.14	4
Cooperative Extension Serv.	1.04	7	1.23	4 c/	1.10	7	1.12	5	1.12	6	1.09	6
Commercial Newsletters	0.91	12	1.26	3 c/	1.23	4	0.93	13 c/	1.06	9	1.17	3
USDA and Government Pubs.	1.00	9	1.04	9	1.02	10	1.00	9	1.01	12	1.00	8
Salesmen	1.03	8	0.99	12	1.08	8	0.94	12	1.09	7	0.70	15 c/
Television Reports	1.07	6	0.91	16 c/	0.94	13	1.06	6	1.01	11	0.95	11
Other Farmers	0.97	10	1.03	10	1.04	9	0.95	11	1.06	8	0.70	16 c/
Accountant	0.92	11	1.00	11	0.87	15	1.04	7	1.03	10	0.64	19 c/
Crop Reporting Service	0.90	15	0.97	14	0.89	14	0.98	10	0.94	13	0.88	13
Marketing Consultant Serv.	0.73	19	1.11	8 c/	1.00	11	0.79	17	0.89	15	0.93	12
National Newspapers	0.83	16	0.92	15	0.81	16	0.93	15	0.80	19	1.04	7 c/
Tax Preparer	0.90	13	0.80	18	0.81	17	0.93	14	0.91	14	0.68	17
Computerized Info. Serv.	0.74	18	0.97	13	1.00	12	0.72	20	0.82	17	1.00	9
Local Newspapers	0.90	14	0.70	19 c/	0.75	19	0.91	16 c/	0.85	16	0.72	14
Lender	0.73	20	0.80	17	0.76	18	0.79	18	0.80	18	0.63	20
Veterinarian	0.78	17	0.59	21	0.62	21	0.77	19	0.78	20	0.31	21 c/
Attorney	0.55	21	0.56	22	0.49	22	0.60	21	0.60	21	0.28	23 c/
Brokerage Firm	0.39	22	0.64	20 c/	0.64	20	0.38	23 c/	0.46	22	0.68	18
Insurance Agent	0.39	23	0.33	23	0.33	23	0.41	22	0.39	23	0.30	22

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.

Table 2. Computer Use on Commercial Farms By Farm Size and and Farm Type, Ohio, 1987.

Item	All Farms	Grain	Dairy	Mixed Livestock
NUMBER OF FARMS	716	196	230	206
OWNERSHIP OF COMPUTERS BY:		percent		
farms within each category	13.2	11.7	12.1	16.9*
grain farm size:				
600 acres or less	----	3.7	----	----
greater than 600 acres	----	21.3[a]	----	----
dairy farm size				
60 cows or less	----	----	8.8	----
greater than 60 cows	----	----	18.0[a]	----
USES OF COMPUTERS BY FARMERS USING COMPUTERS:				
business accounting	61.6	80.6*	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*	48.1
access to electionic info.	19.2	25.8	13.7	19.2
MOST IMPORTANT USE OF COMPUTER:				
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*	7.6
access to electionic info.	1.3	3.2	2.0	0.0

* Denotes significantly different from other farm types (5 percent test level).

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