ELECTRONIC TECHNOLOGY AND MANAGEMENT INFORMATION IN AGRICULTURE

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Recent developments in electronic technology offer possibilities for management information systems in agriculture, which differ radically from traditional information sources. This paper illustrates how all the elements are now available for an integrated farm office workstation, allowing financial planning and control, livestock and paddock database management, access to large commercial databases, and electronic selling of produce, banking and communications. Although the outlay required for this new technology is small relative to plant and equipment items, adoption by the Australian farming community has been slow. It is argued that the rate of diffusion has been limited more by educational and psychological factors than by the adequacy and cost effectiveness of the new technology. Government and industry initiatives to promote adoption are reviewed.

Keywords: electronic technology, management information systems, agriculture, diffusion, policy measures

INTRODUCTION

Information technology for farmers has changed dramatically in the last decade. Up until the late 1970s, the main sources of farm business information were radio, newspapers, journals, extension leaflets and personal communication with advisers and other farmers. Recording and analysis of physical and financial data about the farm business were carried out by manual systems, with small numbers of farmers subscribing to bureau services or employing farm secretaries. The advent of low-cost microcomputers in 1976 and the launching of British Prestel videotex in 1978 heralded a new era in access to farm management information.

Electronic technology now available to farmers offers a number of benefits in terms of more immediate and detailed physical and financial information about their on-farm and off-farm investments, reduced transaction costs and better communications. In practice it is extremely difficult to place a value on these benefits. However, electronic information technology is being adopted increasingly by

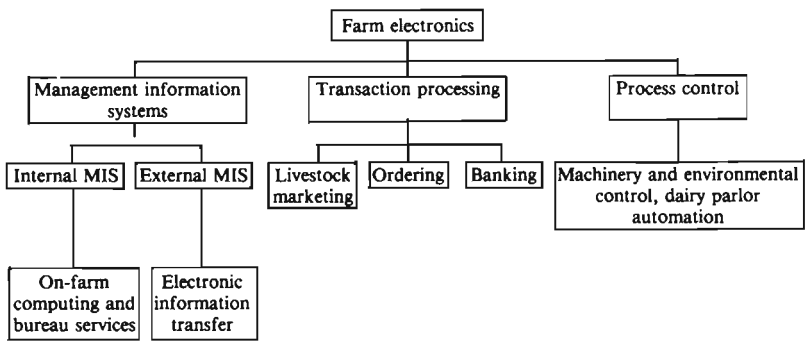
farmers in the USA and Britain, and it would seem likely that substantial public and private benefits would arise if Australian farmers were to follow suit. An understanding of the progress, experiences and problems of early adopters can shed light on how to encourage further diffusion of this new technology.

This paper examines electronic information technology applicable to managerial decision-support in farming, and obstacles to its diffusion throughout the farming population. First, the current state of electronic information technology is reviewed. The potential market for this technology and progress in adoption are then examined. Next, reported evidence of experiences of software vendors, information system providers and farmers is discussed. Finally, the role of government and industry organisations in overcoming obstacles to diffusion of electronic information technology in agriculture is examined.

CURRENT TECHNOLOGY

The application of electronic technology to farming, or *farm electronics,* may be divided into a number of separate aspects, including management information systems, transactions processing and process control. Each of these may be further divided, as in Figure 1.

FIGURE 1



In the scheme of Figure 1, management information is seen as arising out of the analysis of performance data generated by the farm business and from access to large external databases. These internal and external management information systems (MIS) of course

operate alongside traditional decision-support systems such as printed media and discussions with advisers and neighbours. Data generated within the farm business may be recorded and analysed by a bureau service or on the farmer's own computer. Bureau services have been available since the 1960s, the Queensland Department of Primary Industries being one of the pioneers in this area.[1] Subscription to a bureau service avoids initial outlays on equipment, and is sometimes viewed as a means of getting started with an electronic information system.[2] Since the advent of the microcomputer, software developers have concentrated on packages for on-farm computers, due to the potentially greater volume of software sales. The on-farm computer offers advantages in timeliness of information, data security and flexibility of analyses.

Transaction processing has been defined to include electronic banking, shopping, travel booking and the downloading of software.[3] An addition to this list in the case of livestock producers is computer aided marketing. While these applications are not strictly information systems, one of the major advantages of computer aided livestock marketing is the additional market information it provides to the producer.

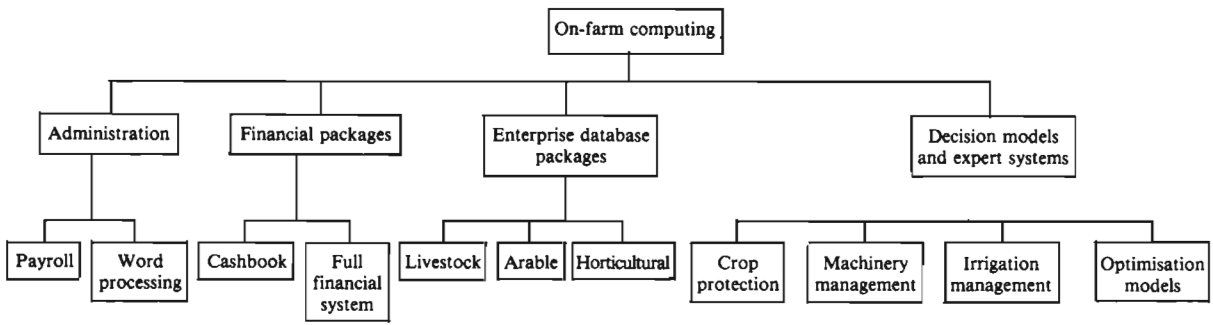
Microelectronics are being used increasingly in process control in farming; for example, in the automation of glasshouses and dairy sheds. These applications will not be discussed further here.

ON-FARM COMPUTING

A variety of farm management techniques has been devised for mainframe computers. From an early preoccupation with record keeping and comparative analysis (efficiency indices), the methodology evolved through full accounting systems, linear programming and complex simulation models. The state-of-the-art microcomputer is capable of performing most if not all these forms of analyses, and usually more quickly and conveniently (interactively) than predecessor machines. In fact, the evolution of farm management techniques on microcomputers appears to be repeating that on mainframes. Early emphasis of database management has given way to financial recording and planning packages, while more complex decision models (including expert systems) are now being developed.

On-farm computing is defined here as the use of software packages for data recording, data analysis, computer programming, wordprocessing, or other activities on a microcomputer (or minicomputer) in the farm office. Directories have been compiled of software available for microcomputers in Britain[4] and in Australia[5].

FIGURE 2


On-farm computing
Administration
Financial packages
Enterprise database packages
Decision models and expert systems
Payroll
Word processing
Cashbook
Full financial system
Livestock
Arable
Horticultural
Crop protection
Machinery management
Irrigation management
Optimisation models

On-farm computing may be divided into administrative applications; financial recording, analysis and planning; enterprise database applications; and decision models. These may be further dissected as in Figure 2.

The processing of wages has been a major reason for computerisation outside agriculture, and has been an early application on farms with even small labour forces[6]. Wordprocessors are often provided as 'bundled software' with microcomputers, and offer considerable potential for farm correspondence[7]. More relevant for providing managerial information are financial packages, and it is generally considered that these should play a central role in any on-farm computer system[8]. Financial packages vary from relatively simple electronic cashbooks to complex financial recording and forward budgeting systems. The latter typically include capabilities for profit and loss statements, cash flows, enterprise reports, budget comparison, analysis by code, cheque reconciliation and audit trail. While double-entry recording systems are available, these are not widely employed by farmers.

One of the earliest commercially promising applications of computers to farm management was the Daisy dairy system developed by Reading University, and based on the Melbred recording system (which was devised jointly by the Universities of Melbourne and Reading). Following Daisy, various dairy packages for microcomputers which use modern database management techniques have been marketed. The essential feature of these is that each cow corresponds to a *record* in the database, and each piece of information about the cow (date of birth, lactation number, last calving date, supplementary feed allowance, milk production, etc.) is entered in a separate *field*. Elimination of data redundancy, direct (rather than sequential) access to individual data items, multiple views of data, simplicity of updating and ease of selecting subsets of information made this the basis of a versatile management information system. These packages are used to produce *action reminder lists* (e.g., when to dry-off cows) and for *specific interrogations* (e.g., to identify low milk producers for culling). Enterprise database packages are also available for pigs, beef and sheep, and especially stud stock. As well, they have been developed for crop management, in which case the paddock forms the recording unit, and database fields are included for items such as paddock number, size and area; previous and current land use; and fertiliser type and rate. Paddock database systems are used to obtain performance criteria such as gross margins for individual paddocks, and to obtain aggregate data such as fertiliser applied and crop production over the whole farm.

Crop protection packages have been devised which make use of so-called "expert systems", examples being the CSIRO's Siratac[9],

Croplan's Epipre and ICI's Counsellor. The optimisation technique of linear programming has been promoted for solving farm planning and feedmix problems[10]. A number of other decision models for machinery, irrigation and livestock management are available, but have not been widely adopted.

ELECTRONIC INFORMATION TRANSFER

Various systems are available by which farmers may access information from large central databases, often located interstate or even overseas. The term *videotex* is used to describe information systems making use of adapted television sets to display pages of text and pictorial material[11]. This includes two-way or interactive communication over the telephone network (*viewdata*) and one-way broadcast (*teletext*). Videotex services, such as British Prestel[12], Teletel in France, Telidon in Canada and Australia's Viatel, are available 24 hours a day and provide access to huge databases of both general and specialised information. Some of the pages in these public videotex services are of particular interest to farmers. As well, closed user groups may be set up to cater for users with common interests. For example, Country-Wize Pty Ltd have recently launched a user group for Australian farmers within Viatel. Subscribers pay $210 a year, and are not levied any page charges. Information is supplied about weather, markets, new technology; farm accounting, finance and insurance; irrigation and spray schedules; livestock and crops; and transport. A country magazine section provides details of recipes, wines and even first-aid treatment for snake-bite! A classified advertisements section is included. It is envisaged that 25,000 'frames' of information will be placed on the system. A number of private videotex services have also been set up for farmers. Elderlink (previously Elder's Farmlink) in Australia has approximately 1200 farmer clients, and offers over 100,000 frames of information covering a broad range of topics. The Victorian Department of Agriculture and Rural Affairs, with the assistance of the State Bank of Victoria, has become an information provider with their service known as Agtex, which can be accessed through Elderlink or Viatel. An alternative to viewdata is to access information through a microcomputer, as in the Grassroots system in Manitoba and Information Express (incorporating AgriData) in Australia; these are referred to as *videotex-like* systems[13]. Information Express now offers farmers approximately 18,000 regularly updated 'reports' of various lengths, about 8,000 of which are of overseas origin. This service is particularly strong in the international finance and commodities areas. Teletext (e.g., Seventel) is more limited than videotex and

videotex-like systems; a smaller range of information is continuously cycled during the field blanking interval of broadcasting, and is available only when the channel is on-air. Communication outwards is not possible, and high value information tends not to be available since no page charges can be made for access.

Evidence suggests that the greatest demand from farmers is for frequently changing market-related information[14]; financial information (especially share and futures prices) and frontier technology (e.g., insect control recommendations)[15]; information on products such as building materials[16]; and sports results and local weather and social news. The interest in these types of information would presumably arise from timeliness (product and finance markets), convenience (new technology) and interest (sporting and social news). Australian experiences in adoption of videotex are discussed by Richardson[17], while Collard *et al.* have evaluated services for beef producers[18].

TRANSACTIONS PROCESSING

A number of commercial and semi-commercial livestock marketing systems have been trialled in Australia, in which auctions are conducted using a central computer to receive bids, convert them to a standard basis, conduct the auction and prepare post-sale documentation. With appropriate equipment, producers or their agents can participate in or observe these auctions. Under the New England Livestock Computer Marketing Scheme (NELCM), which is reputed to have sold more cattle electronically than any other scheme in the world[19], 'lots' of fat and store cattle and lambs are auctioned by description, with simultaneous bidding over a wide area by phone and telex. Computer Livestock Auction Selling Services Ltd (CLASS) of Western Australia is based on NELCM. Elders Pastoral Company have established a system of 'video auctions' in which a written description of stock is supplemented by video film. The Queensland Electronic Stock Trading scheme (QUEST) differs from the above systems in that individual carcase pricing is adopted; the buyer bids for a schedule of quality versus price, specifying price discounts for departure from nominated carcase weight, fat thickness and dentition[20]. A national scheme of computer aided livestock marketing (CALM) sponsored by the Australian Meat and Livestock Corporation and franchised to Mayne Nickless is now under development. The CALM system is expected to be in operation by the end of 1986, and will sell cattle, sheep and pigs. It is claimed to be the first ever commercial nation-wide computer livestock selling system[21]. The NELCM and QUEST selling systems are both to be available under CALM, and it is expected that Elderlink clients will have access

to the new system. A competitive system for pigs (LEAD) has been devised by the Australian Council of Livestock Agents.

Computer livestock marketing schemes have a number of advantages over traditional saleyard selling. Transport costs, stress to animals, weight loss and bruising are reduced since stock do not need to be transported to saleyards. Graziers can 'no-sale' stock, at least in the short run, if they consider prices too low. Potentially, agent fees are reduced and competition is improved by affording access to stock buyers from a wider catchment. Since the buyer does not see the animals he purchases (except perhaps on film), price adjustment is usually possible to correct for misdescription. Under the QUEST scheme, the seller is spared the expense of mustering prior to sale, and can even choose the beasts he wishes to sell after the auction, since the buyer's price schedule accommodates quality variation. Each of the schemes provides immediate market information for a wide geographical area; QUEST reveals not only what buyers are willing to pay for a particular lot of animals, but also how they discount the price for carcase quality variations, a useful guide when deciding what type of beast to produce. On the other hand, saleyard auctions are a regular meeting venue for livestock producers, and provide an occasion for informal information exchange and decision support not limited to livestock marketing. There is a danger that CALM will capture mainly the larger stock transactions, increasing saleyard costs for smaller producers.

Telecom's Viatel now offers telebanking (electronic bill paying, transfer of funds between accounts and immediate information on account balances), travel and entertainment booking, telebetting on race meetings, telebroking (buying and selling of shares and other securities), telex and electronic bulletin boards.

DIFFUSION PROGRESS

Given the scope for improved information and more efficient trading, it is pertinent to enquire as to the extent to which the farming community has taken advantage of these new opportunities for improved decision making. Although a substantial literature exists on diffusion of technological innovations[22], the theoretical background for examining the diffusion process is still controversial, and the validity of many diffusion models is questionable[23]. In this section, diffusion of EIT is examined in terms of potential market, and evidence of adoption in this market.

Potential market

Although EIT has been widely accepted in industry, its relevance to farmers has been a matter of debate in the literature. Hardaker and

Anderson estimated that in 1981 less than one half of one per cent of Australian rural producers were using financial recording schemes (either manual or computerised) together with some processing to obtain measures of financial performance[24]; further, they concluded that these systems were doomed to failure because they do not meet the needs of farmers, a view strongly contested by Richardson[25] and Nuthall[26].

The market for EIT in agriculture may be examined from an assessment of which farmers would be likely to benefit, or by examining the characteristics of farmers who have actually invested funds in this technology. As a starting point, the potential market may be taken as all commercial farms[27]. To this may be added agribusiness firms and rural consultants. Another group of potential adopters is hobby farmers, the number of which appears to be growing in Australia.

Evidence as to whether adoption of EIT is dependent on the type of farm is inconclusive. Banfield and Cory found no relation between size and complexity of farm business and purchase of on-farm microcomputers[28]. On the other hand, the Agricultural Development and Advisory Service (ADAS) in Britain suggests microcomputers would be most likely to be justified on estates owning more than one farm, and on medium to large dairy, pig and poultry units[29]. Pugh goes further and lists the characteristics of farms (and their managers) for which purchase of a microcomputer would be justified, and derives a scoring system over the various characteristics; if a farm achieves a sufficiently high score then a computer is considered a viable proposition[30] A survey commissioned by the Centre of Management in Agriculture (CMA)[31] indicated that farms on which computers were used for business purposes tended to be larger than average, and have a greater than average number of employees. Adoption was widely distributed across regions and farming types, with a slight concentration among cereal and dairy farms, and in Scotland and the Eastern Counties. In a Queensland study, Delaney found personal attributes of the farmer more important than those of the farm, in characterising videotex adopters[32]. Adopters were not younger or better educated than average; most were active information seekers, and carried out their own record keeping (rather than, say, relying on their wives).

Ideally, one would carry out an economic (cost/benefit) evaluation of any particular electronic information application to determine whether the investment is warranted on economic grounds. Outlays on hardware and software, and operating and maintenance costs, are reasonably easy to estimate. Microcomputer prices are typically of the order of $2000 to $5000, and printers and software packages each around $500 to $1000. The total outlay on a microcomputer system

suitable for farm business purposes is therefore typically about $5000 to $7000, which is small relative to items of farm machinery. Videotex services vary considerably in price. The subscription fee for Elderlink is $149 a year if the farmer provides his own microcomputer, or $499 a year if equipment is leased. The cost of hardware for accessing Information Express varies between $1000 and $5000 approximately. A joining fee of $126 is payable. No annual subscription is required if the system is used only in off-peak periods; at the other extreme an annual charge of $399 a year is made for premium access service. Under both Elderlink and Information Express, communications and computer connect charges of approximately $500 to $1000 a year could be expected, depending on amount of usage. However, information systems are an 'enabling technology' rather than a production process with quantifiable output, and financial benefits are difficult to assess. ADAS case studies of 174 farmers using computers identified a number of benefits: less time spent in the office (especially by pig producers and when using payroll packages); cost savings from financial packages; better control of cow breeding and fertility; personal interest and education benefits[33]. The cost saving in cases where the wage bill for clerical staff or accountancy fees are reduced is a direct and estimable saving. Benefits are certainly likely to accrue from more timely, convenient and complete information, but it is no simple matter to place a value on these. Statistical models have been devised to measure the value of perfect and imperfect information[34], but are not readily applied to complex decision situations. Also, it is difficult to attach a money value to non-business benefits in terms of entertainment (computer games) and computer literacy of the farm family.

While a discounted cash flow analysis will provide an indication of the desirability of investment in electronic information technology, perhaps the most serious limitation of this technique is that individual components of new information technology cannot be evaluated simply as add-ons to existing information-gathering and information-using processes of farmers. Maximal benefits will only be achieved when these new processes are integrated with each other and within the overall management framework. The time can be envisaged when the farmer will use his computer as an integrated office workstation, providing facilities for: access to information on crop and stock husbandry (including expert systems for crop protection advice); financial recording, planning and accountancy; product information and ordering; marketing of produce; direct deposits of sale proceeds and bill paying; telephone and telex communications; and access to local community news. Such an integration is already technically feasible, but has not yet taken place. Further software development, promotion and evolution of information using habits can be expected

to make the total farm office workstation a reality within the next decade. Indeed, the time may not be far off when it will be a substantial inconvenience not to adopt this technology. Thus, even if it were possible to place a value on existing electronic information technology to farmers, the rate of enhancement in this value due to more efficient use of information, further technological breakthroughs and institutional change is impossible to estimate with any degree of accuracy. In fact, surveys have indicated that expected profitability is seldom the reason for adoption of new technology[35]. It is not surprising that few farmers have carried out any budgeting of expected costs and returns before purchasing a computer[36].

Adoption rates and patterns

Because relatively small numbers of farmers widely spread between industries and regions have adopted electronic information technology, surveys on adoption are difficult to conduct. Further, software vendors and private information system operators regard numbers of clients as confidential information. Much of the initial progress in on-farm computing took place in Britain, where in 1980 approximately 200 farmers were using computers for business purposes[37], and it was estimated that five per cent of commercial farmers could justify use of a computer[38]. The CMA survey in 1984 indicated that the number had risen to about 6200 (just over five per cent of the farming population), a figure confirmed by ADAS estimates of aggregate sales by vendors[39]. The CMA study also revealed that a further 5600 farmers were actively considering purchase of a computer. There was a parallel increase in the number of firms producing software specifically for farmers, from 'half a dozen' in 1980 to 20 in 1981, 32 in 1982, 47 in 1983 and 63 in 1984. Since then vendor numbers appear to have decreased[40] In 1983 ADAS estimated that 10 to 15 per cent of British commercial farms could justify the purchase of a microcomputer[41]. This has been a classic case of diffusion progress, with adoption at an increasing rate and revision of the ceiling of potential adopters as the technology improves[42].

While no authoritative data on the number of Australian farmers using computers for business purposes are known to the author, it is unlikely that the total would be as great as in Britain. Both the Kellogg Farm Management Unit and Shannon Robertson have sold around 500 systems to farmers[43], and these are two of the major providers. (A total of approximately 40 Australian rural software vendors are listed by Mickan[44], although only about half a dozen of these offer a broad complement of accounting and physical recording packages.) It has been claimed that Britain is at least two years ahead of the USA in on-farm computing[45], and that Australia lags Britain by five years[46].

These gaps are probably narrowing. A number of possible explanations may be advanced for the British success. Much of the progress appears to be due to the initiatives of a small number of farmers-cum-entrepreneurs, who initially had software written for their own operations, and subsequently established agricultural software companies. The recognition and assistance afforded by the agricultural computing team of ADAS has no doubt assisted these firms. Presence of large multi-unit estates, intensive nature of farming, high value of production units (e.g., of dairy cows) and relatively high education levels of farmers have no doubt been other factors in the more rapid rate of adoption in Britain.

Evidence indicates that the most popular packages have been those for financial management. In British case studies of 174 farmers using computer programs, 70 per cent had adopted a financial package, 53 per cent a dairy package, 27 per cent an arable package, 11 per cent a pig breeding package, with smaller proportions using beef, sheep, horticultural, poultry and other packages. Hall *et al.* found evidence of a dominance of financial packages in Australia[47].

Although the uptake of British Prestel was disappointingly slow, Teletel in France has been highly successful. Adoption of Australia's Viatel has exceeded expectations: since launch in February 1985 until September 1986, 20,000 subscribers have been signed up, approximately 40 per cent of these being business users. No figures for farmers are available; these could be included among both business and non-business users. Elderlink have approximately 2000 subscribers (800 staff and 1200 farmers)[48], while Information Express has between 500 and 1000 subscribers, between 30 and 40 per cent of which are rurally based[49].

Availability to farmers of information about farm electronics could be expected to have an important bearing on adoptions. In this regard the demonstration effect of farmers currently using computers and happy with their experience may stimulate further adoptions. The finding by Delaney that videotex subscribers had obtained information about the system almost exclusively from vendors rather than other farmers[50] suggests that little such demonstration effect has yet taken place in Australia.

User experiences

Microcomputer systems designed specifically for farmers have been available since 1978, and a good deal of experience has now been gained about problems facing adopters. Early adopters were in a sense 'guinea pigs', ironing out the inadequacies of the systems, and suffering a good deal of frustration in the process. Hardware has now improved and software matured to the point where the technology is

potentially usable by the majority of farmers, although substantial learning time is still needed. Farmers' traditional interests in machinery have led to a preoccupation with hardware[51], whereas choice of system is more appropriately based on software supported.

The most successful software has been that 'written by farmers', or more precisely designed by farmers and written for them by skilled programmers[52]. Experience has shown that software packages need to be easy to use (error free, menu-driven, with a readable manual and perhaps a tutorial and on-line help); comprehensive; flexible; and expandable. Ready access to technical assistance has proved essential, and user groups beneficial. The most trouble-free adoptions appear to have been where the farmer commenced with a relatively easy-to-use package such as an electronic cashbook or payroll package. Cases have been reported of farmers initially purchasing complex financial packages, and subsequently reverting to simpler electronic cash book systems; similarly, there is considerable evidence of initial inappropriate choice of hardware, with subsequent upgrading of drives, monitors and printers[53].

There is controversy as to whether farmers spend more time in the office once they have acquired a computer. Some farmers apparently view their computer system as a substitute for manual recording, which allows them to reduce office time. Others perform analyses that were not feasible previously, such as comparing milk production of progeny of different sires or reconciling monthly actual and budgeted cash flows; this of course increases office time but yields more detailed management information. Evidence suggests that the former view is more prevalent[54], although it is still early days in on-farm computing and more imaginative uses can be expected to emerge over time.

Experience with information transfer and transaction processing systems is of shorter duration, and limited observations of farmer reactions are available. Videotex receivers are simpler than computers to operate, and have been readily mastered, although locating particular information in huge databases has presented problems. Various access procedures have been adopted (e.g., keywords, tree searches), and failure rates in locating data items of 20 to 40 per cent have not been uncommon[55]. Indications are that videotex has yet to make a substantial impact on management. For example, Delaney found that nine per cent of a group of adopters had cancelled their subscription, and the majority of the remainder expected to use the system for not more than one hour per month, the minimum for which they had subscribed[56]. Delaney further noted little change in the use of other information sources. A survey of farmers selling cattle through QUEST revealed that 80 per cent considered they had received above saleyard prices (some of the respondents actually based this conclusion on split consignments)[57]. However, in a period of

falling cattle prices, farmers tended to place unrealistic reserves on their cattle, which consequently were not sold[58].

Although occasional problems have been experienced with low humidity, dust, variable power supplies and poor telephone connections, in general electronic information equipment has proved highly robust to the variety of environmental conditions experienced in Australia. Overall, farmers appear to have been well satisfied with their electronic information systems[59], which is consistent with the experience overseas[60,61].

Experiences of software vendors and information system operators

Because software production requires little capital, a large number of firms have set up in the agricultural software industry. However, the market has proved to be highly competitive with a high failure rate of participants[62]. As the market has matured, farmers have come to expect high product quality, and now months and even years of effort are required to develop and promote a software package, with a real cost of $60,000 being not unusual[63]. After the early enthusiasts, farmers have taken a more business minded approach to purchase of computer systems; for example, Farmplan has experienced a sales pipeline in which an average of five man-days over six months are required to sell each on-farm system[64]. Follow-up problem solving, careful selection of local agents and fostering of user groups has been necessary for continued sales. Software vendors have tended to increase the range of packages offered over time, and some have diversified beyond the agricultural market (e.g., into real estate management software). Given the development costs, it would appear that vendors have not made large profits to date, a view supported by discussions with representatives of various firms. Much of the investment has been to gain a foothold in an industry which is expected to expand rapidly in the future. It is anticipated that sales of updates and new products to existing clients will soon bring in more revenue than new business.

Most agricultural software appears to have been written in the BASIC programming language, though interest is now being turned to other langauages, such as "C". Multipurpose packages, particularly spreadsheets and databases, have been used for creating 'template' applications software. Perhaps greater use should have been made of so-called 'fourth generation' information management languages such as SQL, Knowledgeman and dBase 3+, since these can drastically reduce program development and maintenance time[65]. Few farmers have to date purchased microcomputers with sufficient memory for fourth generation software, but memory prices have dropped dramatically in the last year.

While some of the early programs were designed specifically for individual farmers, program development is a costly process, and attention is now concentrated on development of more general off-the-shelf packages. Flexibility has been retained by offering farmers a menu of reports from which to choose (e.g. Farmplan Financial and Kellogg Financial Recording System) or allowing the farmer to tailor make his own reports (e.g. Shannon Robertson's General Accounting System).

The market for rural videotex services is also highly competitive, and it is unlikely that there is room for more than two or three market participants in Australia. Profitability to both system operators and information providers depends on size of audience. It has been necessary to have a large user base to attract information providers, but availability of a broad range of information is necessary to enlist subscribers. Information Express has overcome this chicken-and-egg problem by broadening their customer base beyond farming.

OBSTACLES TO ADOPTION

In the past, availability of relevant and easy-to-use software has no doubt been a major restriction on the adoption of on-farm computers. While this limitation has largely disappeared, a number of factors hampering adoption remain. Foy identifies these as fear of the implications of computer based information systems; poor computer literacy skills among farmers; lack of retail marketing and support infrastructure; and cost-effectiveness of the investment[66]. To this list must be added farmers' conservatism and resistance to change, and the time demands and emotional trauma of coming to grips with a new and foreign technology. As well, in the case of services such as electronic banking there will no doubt be fear as to the security of funds and confidentiality of transactions. For example, it is doubtful whether farmers would trust any system that did not include 'hard-copy' of documents such as receipts and account sales, at least in the short term. Falling hardware prices, increasing popularity of home computers, and emphasis on computer literacy in schools should gradually reduce these barriers to adoption.

It is often stated that farmers cannot be expected to adopt videotex when most of the same information is available for a fraction of the cost, either immediately by telephone or with a time delay of a few hours (radio) or up to a week (rural newspapers). Unlike, say, dealers in the international commodities or money markets, farmers do not frequently make decisions which require instant information. Farmers in the USA have been found to rank three conventional sources of information (newspapers, radio and buyers) ahead of viewdata

systems[67]. This is perhaps a premature comparison in that videotex operators are still expanding their databases and developing new services, e.g., share trading and monitoring the value of a share portfolio.

Introduction of electronic livestock marketing systems has involved substantial co-ordination and overhead costs of equipment and experimentation. Part only of this cost could be met by users; NELCM has received approximately $1 million in government and industry funds, while livestock producers have agreed to levies totalling $2.8 million over five years to fund the national Computer Aided Livestock Marketing (CALM) system[68]. In spite of considerable resistance from farmers unfamiliar with electronic technology, from agents who have feared loss of jobs, and from meat processors who are reluctant to buy stock sight-unseen, the national scheme is now ready for launch.

The rate of adoption of electronic information technology is likely to remain slow while farmers purchase computers for single purpose applications such as farm record keeping, videotex or livestock marketing alone. Adoption rates may accelerate when the elements of an integrated farm office workstation come together; with sophisticated software and ability to carry out transactions and send and receive information, the computer will play a fundamental role in management of the farm business.

IMPACT ON AGRICULTURAL EXTENSION

Electronic information technology has the potential to radically alter the methods of extensions services provided to farmers by state agriculture departments and industry organisations. The balance of farmers' information-seeking and information-using methods seems certain to change over time, and extension services will need to keep abreast of these changes, or risk becoming less effective and less influential among farmers. For example, the accounting procedures employed by farmers are likely to be those provided in financial recording packages, which may well differ from methods advocated by the farm management profession[69].

Although governments may not wish to incur the overheads of setting up their own videotex systems, it would seem desirable that they at least become information providers in existing commercial services. They have the responsibility of regulation and standards, of which farmers could be made aware through videotex. They possess information not available from commercial sources, e.g., the Queensland Department of Primary Industry's survey information on crop sowings and anticipated yields. The primary role of extension

services in providing crop and livestock husbandry advice to farmers could be strengthened by providing on-line services which are instantly available to both advisers and farmers. Authoring packages for expert systems now becoming available offer exciting possibilities for improving the accessibility of husbandry information, particularly for crop protection. Agriculture departments could also provide unbiassed information where private vendors have a commercial interest, and information on long term issues not well handled by private sources (e.g., soil conservation)[70]. The Victorian Department of Agriculture and Rural Affairs now offers its Agtex service, while other state agriculture departments have been actively investigating provision of videotex services.

GOVERNMENT AND INDUSTRY SUPPORT

Given the managerial efficiency and social impacts of electronic information systems, decisions will have to be made as to the extent of government support, promotion and regulation of this technology. Government policies to increase the uptake of new technology have been divided into two broad groups, *viz.*, subsidies and information provision[71]. Both types of policy increase use, but the latter is preferable on welfare grounds[72]. A subsidy component has been involved where government agencies have developed agricultural software. As indicated earlier, private software vendors in Britain are assisted, and informally regulated, by the Agricultural Computing Team set up within the Ministry of Agriculture, Food and Fisheries. This unit provides information to farmers about software available, though it has resisted pressures for 'choice' type evaluations of competing packages, on the grounds that such evaluations are not their role and in any case would be of limited value given the rapid evolution of software. In the USA, Australia and New Zealand, universities and state agriculture departments have played a relatively more important role in software development, though private vendors have now entered the market. The Kellogg Farm Management Unit in New Zealand operates on a semi-commercial basis; software is priced at little more than cost, production being assisted by grants from the Kellogg Foundation. A number of accountancy firms are now marketing software for farmers, and overseas-based vendors such as Farmplan have established local agencies.

State agriculture departments have developed software for extension workers, but rarely for farmers. Creation of a national agricultural computing unit like that in Britain could greatly encourage adoption of on-farm computing and videotex. The newly established Centre for Electronics in Agriculture at the University of

New England could possibly fulfil this role. However, the effectiveness of any national unit would be limited by the vast distances between farming areas in Australia and state responsibility for agricultural extension. It is to be anticipated that state agriculture departments will increasingly adopt videotex technology as an integral part of their extension and regulatory activities.

Telecom's Viatel now provides a low cost general purpose videotex service, in competition with private services. Also, substantial amounts of government and industry funds have been spent on development of computer livestock marketing, as indicated above.

Taxation policy can have a substantial effect on diffusion of electronic information technology. Currently a 150 per cent deduction is allowed for research and development expenditure, including development of computer software. However, the full allowance applies only to companies spending more than $50,000 a year on research and development. Removal of the investment allowance in July 1985 has made purchase of any computer equipment less attractive. Also, the revised basis of calculation of sales tax on software introduced in the 1986 Federal Budget will substantially increase software prices[73]. The statutory requirement for value-added tax (VAT) returns has encouraged adoption of financial packages in Britain, and modifications now being made to New Zealand financial software to accommodate the goods and services tax (GST)[74] appears to be having the same effect. Increasing requirements for statutory returns from Australian farmers, such as associated with fringe-benefits taxes, may also make a computer a more necessary acquisition.

Adoption of home computers for games purposes has contributed substantially to computer literacy in the community. The teaching of keyboard and programming skills, information system concepts[75], spreadsheeting and so on has at last commenced in Australian schools, and this will no doubt make the next generation of farmers more at home with computer technology. In the meantime, access is available to short courses on microcomputing through TAFE colleges and Continuing Education establishments.

CONCLUSIONS

Availability of microcomputers and videotex receivers for farmers is of recent origin, and the proportion of farmers now using this new information technology is small. However, earlier negative views about electronic information systems on the farm have proved unfounded. The on-farm computer can now perform all the forms of data recording and analysis conceived by the farm management

profession, and has sufficient speed, capacity, and mechanical reliability to be used effectively in the farm office environment. On-farm computing is being adopted by Australian farmers, though not as rapidly as in some overseas countries, notably Britain. Substantial progress is also being made in videotex and videotex-like services, and in electronic livestock marketing. The value of each of these developments to an individual farmer cannot be assessed in isolation; rather, they need to be considered within the total information and decision-making systems of the farmer. Evidence suggests that adopters are well satisfied with the technology, and future developments may well make the integrated electronic workstation an essential office facility for efficient farming.

Agricultural extension advisors (including farm economists) will need to understand and adopt this new technology, or risk losing the initiative in influencing husbandry and management standards of their farmer clientele. State agriculture departments are commencing to take up this challenge.

The diffusion rate of electronic information technology has varied between farming industries, regions and countries, as well as over time. A number of obstacles to further progress remain; these relate more to psychological and educational factors than to the adequacy of the technology. Federal and state governments can influence the diffusion rate through financial assistance, tax legislation and education programs. Australian governments have strongly supported the development of computer aided livestock marketing and promoted videotex, but have been less supportive of on-farm computing. Yet it is this latter application which has proven most useful to farmers overseas.

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