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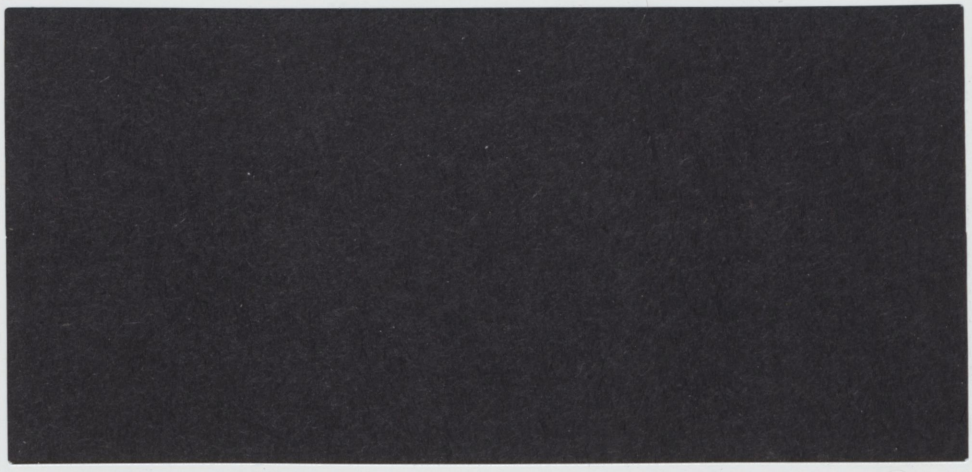

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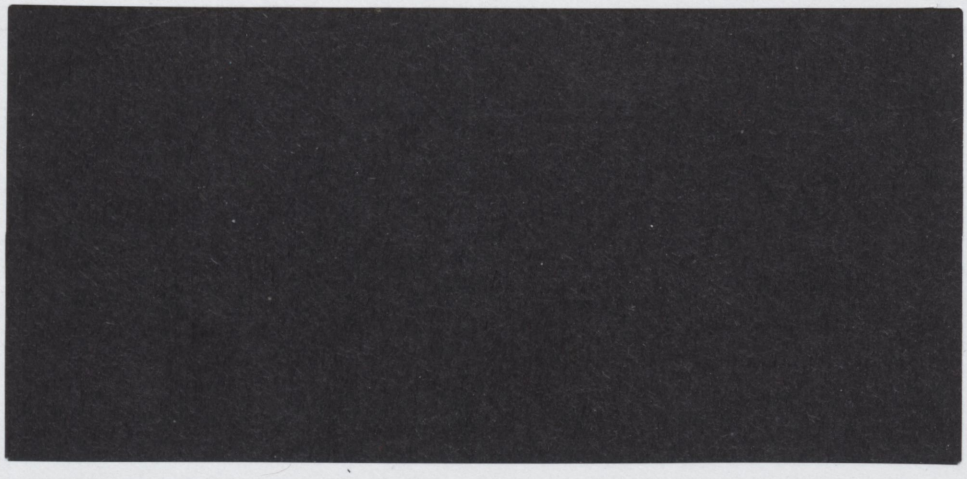

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THE ECONOMIC BENEFITS OF NEW INFORMATION TECHNOLOGY

Working Paper 3/96

by

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EXECUTIVE SUMMARY

The purpose of this study is to analyze the demand and supply of information within the agriculture sector. This study has three components to meet this goal: i) a review of the literature, ii) a survey of Canadian farmers, and iii) interviews with agribusiness firms and government agencies. The following are the summary findings from those three sections and conclusions from the analysis.

Summary of the Literature Review

The review of papers on the economics of information with respect to agriculture and the adoption of new information technologies on the farm identified the following major themes:

* Information is both an input in production and a product of a functioning market. As such, it has many aspects.
* Information has value when it affects prior beliefs and/or actions. Information acquires value by enabling people to more effectively see the means at their disposal to achieve their goals. It can also make people more aware of entrepreneurial opportunities.
* Information can be a public good, i.e., non-rival and non-excludeable in consumption, but rival in delivery and commercial use.
* Economics of information can not be separated from subjective perceptions of risk and uncertainty. Moreover, economics of information is closely tied to the agency problems of moral hazard and adverse selection, and the transaction costs of search, negotiation, and enforcement.
* Information impacts production agriculture by affecting the economic quantity and timing of inputs and activities, ranging from quantities of fertilizer, timing and quantity of irrigation, and the timing and efficacy of both risk reducing and production enhancing inputs.
* Farmers obtain information from a broad range of sources, including media and personal networks.
* USDA price forecasts are not significantly different than futures market prices, but there is some evidence that USDA (and other government market information) speeds price discovery and hence decreases deadweight losses due to out-of-equilibrium markets.
* Adoption of new technologies usually follows an 'S'-shaped curve of early, middle and late adopters, but studies of computer use reports more of a straight line adoption curve.
* Computers are adopted by younger farmers who manage larger, more diversified operations.
* There is some worry that new information technologies may contribute to a widening gap between the "haves" and the "have nots" of information.

Summary of the Farmer Survey

The survey of 502 Canadian commercial farmers (i.e., farmers reporting farm incomes of at least $50,000/year) reported the following results:

* About 50% of all commercial farmers have computers, with half of those computers purchased over three years ago.
* Among farmers without computers, cost and lack of need (33% and 32% respectively) were the reasons most cited for not having a computer.

* Younger farmers with more education and larger operations were more likely to have a computer. Enterprise type does not appear to affect the use/non-use decision.
* Major considerations when purchasing a computer included use for farming (84%), non-farm work (76%), and education (88%).
* Computers are used primarily for keeping general farm accounts, and much less for enterprise analysis, budgeting, payroll, and as a decision aid.
* Computers have helped farmers to keep more detailed records, produce financial reports, and know and analyze financial performance more precisely, but most farmers do not think that computers have changed the way they manage their businesses.
* Less than 7% of the farmers surveyed use satellite broadcast information servics or agricultural bulletin boards, 9% are on the Internet, but the attrition rate is very high. For both the information services and the bulletin boards, 4% have used them in the past but no long do so, and 5% have used the Internet in the past.
* Approximately 60%-70% of the farmers surveyed were willing-to-pay for the ability to electronically communicate with their banker, accountant, suppliers, etc., and obtain market information or market forecasts. Slightly less than half were willing to pay for weather forecast information.
* The demand for market information is inelastic, in the -0.11 to -0.12 range; the demand for weather forecast information is elastic (approximately -1.65).
* Video Cassette Recorders are considered an entertainment system rather than an information system. VCRs were reported by 88% of the farmers, with only 2.5% reporting use of educational videos.
* Cell phones are used by 39% of the farmers. While 72% of the cell phone users say their phone is useful for business communications, 83% said that it was more useful for personal communications.
* Only 1.2% (6 farmers) reported having a Geographical Information System.
* Weather information is very important, with probability of precipitation the most important type of information.

Summary of Agricultural Business and Government Agency Interviews

Various agribusiness firms and government agencies were interviewed. Common issues, trends and insights emerged from the interviews.

* Agribusiness firms used computers for accounting, inventory, and in-house email. More firms have email in-house than external email, but most firms are moving towards Internet links, which will allow for external email.
* Many firms have Web Sites, many more firms are planning and/or developing Web Sites, but the costs,benefits and implications of Web Sites are uncertain.
* Calling the Internet a "super highway" is a misnomer. Most users find it slow, cumbersome and not clearly marked.
* Several managers are evaluating the Internet at home for possible business use. Security is a concern for many; i.e., keeping private information "behind the firewall".
* Banks appear to be leading the way in establishing electronic communications with customers. Many banking transactions are done on telephone, and will soon be done through computer links.
* Information services such as DTN, Global Link, Reuters and others may be forced out of business by companies providing the information carried by those services as part of a Web Site public service.

* Real-time market information is used only by large-volume traders. Most firms are satisfied with delayed-time information or even the previous day's closing price.
* The more government involvement with a market, the greater the amount of government involvement in providing information about that market.
* Geographic Positioning (Information) Services (GPS) benefits are still uncertain, but are expected to include more precise fertilizer and other chemical input use, and precise yield monitoring.

Conclusions

Several conclusions emerged from the literature review, the farmer survey and interviews with agribusiness firms and government agencies.

* Information has many characteristics of a public good: it is non-rival and non-excludable in consumption, but does have positive costs of gathering, screening, editing and disseminating.
* Information is subjectively evaluated, hence dependent on an individual's non-observable utility function. However, actions may be observed and stated willingness-to-pay for information elicited.
* Adoption and use of computers on farms will increase as farms continue to increase in size and complexity and farmers' level of education increases. However, the adoption rate is more linear than the usual "*S*-shaped" adoption rate associated with most new technologies.
* The use of computers on the farm contributes to increased managerial effectiveness by making access to farm records quicker and more accurate. Quicker access enhances the monitoring ability of farm managers.
* The importance of information and the ability to communicate is indicated by the inelastic demand for those services exhibited by 60%-70% of the farmers surveyed. For a large proportion of farmers, information and the ability to communicate are necessary and have no real substitutes.
* The possible benefits from the Internet are vast but uncertain at this time. It is likely that many of the pay-for-information services will be replaced by magazine type Web Sites on the Internet. Market and futures prices, and other information will act as a draw to bring farmers to the Web Site, which will also have commercials and information about the sponsoring firm's goods or services.
* Government's role as an "honest broker" of information will likely continue regardless of the technology of the information systems.
* User fees for government supplied information is problematic. Once data is screened and edited into usable information, it is non-rival and non-excludable in consumption; i.e., the main characteristics of a public good.

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1.0 INTRODUCTION

The purpose of this study is to analyze the economics of new information technologies within the agricultural sector in Canada. The study consists of two components:

1) A review of the literature and development of a theoretical model to determine the characteristics of the "market for information";
and

2) Surveys of primary producers and related industries to determine the information sources and requirements of the agricultural sector.

The specific objectives of the project are to:

1) Review the economic literature on the economics of information and develop an annotated bibliography of relevant studies on information;
2) Identify the sources of demand for information on the part of input suppliers, farmers, and processors in the agrifood sector;
and
3) Estimate the sources of supply of information on prices, production and outlook, cost of production, weather, new technologies, and other types of information relevant to the agrifood sector.

The research methods used to meet the above objectives are computer assisted searches of relevant library indices, telephone surveys of commercial Canadian farmers, and structured interviews with agribusiness firms and government employees.

2.0 SCOPE OF PROJECT

2.1 New Information Technology

"New information technology" as used in this study refers to several electronic information and communication systems that have been developed and adopted in recent years. These new technologies lower the cost of editing, screening and compiling data into useable information, increase the timeliness of information by increasing the speed at which the information can be accessed or disseminated, or otherwise lowering the cost of providing or accessing the information. For the purposes of this study these new systems include:

i) computers, and in particular personal computers and the accompanying software developed for financial and production records;

ii) teletext/videotext information systems, such as The Data Network and Reuters, delivered through either landline or satellite;

iii) internet communication services and electronic bulletin boards;

iv) videotape systems (VHS);

v) cellular phones; and

iv) geographical positioning (information) systems.

The adoption and use of these new information technologies have several implications for the agrifood industry. First, the new technologies have increased the ability of individual information users to collect, compile, screen, collate, and otherwise edit data into useable information. This increased ability to create information from data applies to both internal data, such as production and financial records, and to external data, such as prices on regional, national, and international markets. Second, timely information is becoming accessible at a lower cost. Real-time market quotes, outlooks and weather information are available from a number of sources. Third, rural does not necessarily mean remote given satellite up-links and electronic bulletin boards. Moreover, search costs associated with purchasing inputs may decrease as input specifications and ordering becomes possible through internet servers. Fourth, intra-farm communication costs may be decreasing as cellular phones replace 2-way radio systems on geographically spread-out operations. Fifth, much like computers systems, video tape systems can be used for education as well as entertainment. Lastly, in some cases information is becoming more accurate and comprehensive. Geographical Positioning Systems (GPS) can provide very accurate production data to estimate irrigation, fertilizer and other input requirements as well as predict yields from a particular field.

These new information technologies are expected to affect cost, timeliness, and effectiveness of information. Additionally, both sources and users of information will likely shift their information paradigms from a linear system to a nodular system. Organizations that have traditionally been secondary sources of information may find themselves in more of a coaching or facilitating role in an interconnected web system. Information users who used to be at the end of a linear information system will be able to interact with their information sources, and through electronic bulletin boards, become a source themselves in a nodular system.

These changes will impact on the major public and private suppliers of information in Canada and throughout North America. Anticipated changes include how data and information is collected, stored, processed and distributed, all of which has implications for how information and information services are marketed and the proper roles of public agencies and private firms.

2.2 Report Outline

This report is organized as follows. First is a review of literature on the economics of information. This review defines terms and concepts relevant to this study, presents a theoretical base for valuing information from the firm's and society's point of view, and discusses several empirical studies on the value of information in the agrifood sector. Next are the methods used in this study. The theoretical models are revisited in order to explain the empirical models and methods used in a survey of farmers and agrifood firms and agencies. Results from the surveys are then presented and discussed. The report ends with a discussion of the implications from both the review and the findings from the surveys.

3.0 REVIEW OF LITERATURE

The literature on the economics of information has expanded rapidly in the past 25 years, but the value of information is a neglected area. Most contributions have focused on the incentive problems associated with the production and distribution of information. Particular emphasis has been placed on the analysis of the existence and the efficiency properties of market equilibria in contexts where decision makers are less than perfectly informed. Estimation of the value of management information systems or information technology in businesses and other organizations is an increasingly important application of the value of information generally. Evaluation of management information systems has proven to be difficult to undertake with the existing tools of cost-benefit analysis and capital budgeting. The systemic and intangible contributions of information technology to organizational performance, and the synergy between specialized human capital and the realization of those benefits makes it difficult to evaluate investments in information technology. This is not a trivial problem given the growth of investments in Management Information Systems and in Information Technology in both the private and public sectors in the last 2 decades. The adoption and use of information technology in agriculture is in its infancy. Therefore the scope of this survey includes selected contributions to the evaluation of information and information technology outside agriculture.

3.1 Scope of the Literature Review

This survey reviews contributions to the economics of information, particularly with respect to agriculture. Studies that look at the value of information, as well as the technologies associated with the delivery of information and characteristics of who adopts the information technologies, are included in the scope of this survey. Literature from economics, business, and agricultural economics journals and books for the past several years are reviewed, with emphasis on the immediate past as the new information technologies that are the focus of this study have only been available in the immediate past.

This survey does not attempt to summarize the literature on the relationship between the adoption of information technology and the level of employment (for example Laver, 1989 and Plant et al, 1988, National Academy of Sciences, 1987). Issues in the sociology of work and labour relations in an environment characterized by a high level of information technology use (see Simpson and Simpson, 1988) are also outside the scope of this review. Journals searched are listed in APPENDIX I.

3.2 The Value of Information - General Issues

Information is like other factors of production in some respects, but it also possesses attributes that make its contribution to organizational performance quite different than conventional inputs. The production of information uses scarce resources, and hence information itself is a scarce commodity. Information is sometimes bought and sold in commercial transactions, for example in investment newsletters, trade periodicals and newspapers, but its production and distribution is frequently financed through taxation and the information services are distributed to the general public at a nominal charge or for free.

Information is both an input to the functioning of markets and a product of that functioning. Information on recent market prices helps buyers and sellers of commodities to plan production and purchasing. Information about weather forecasts or about pest incidence helps farmers decide what to grow and how to grow it. Once decisions to buy and sell are made and market

transactions take place, prices, the terms at which those transactions take place, convey information to market observers and participants alike about changing demands and supplies of commodities.

Hayek (1945) emphasized that information about production possibilities and preferences is widely dispersed among members of a society and that much of this information is subjective. Hayek's analysis was primarily aimed at providing a critique of central economic planning, but his insights are important to an understanding of nature of information generally. According to Hayek, no single agency or individual possesses all of the knowledge available in a society. Much of the collected stock of information is held as local and subjective knowledge about the productive potential of resources or about preferences and demands for goods and services. Market exchange serves as a sort of laboratory to test the validity of these localized stocks of information. Subjectivism has important implications for the value of information. Perhaps more so than for other goods and services and factors of production, the value of information depends on the subjective mental states of the people who receive it. What people already know, or think that they know, before they receive some information, is an important determinant of the value that they place on that information. What they believe about the credibility of that information, or about the source from which that information is derived, influences that nature of the action taken in response to information. Variations in perceptions or expectations about future economic and social conditions can also have an impact on the actions that a person takes upon receipt of some information. What is information to one person may be quite uninformative to someone else. The value of information, consequently, is likely to vary across individuals.

When people purchase information services in a market, they typically buy something whose contents in detail are unknown. When someone purchases a newspaper, he is buying something precisely because he doesn't know what it contains. He might be familiar with the reputation of the newspaper. He might expect that this particular newspaper publishes stock prices daily. He might be convinced that these price quotes are up to date and accurate. But he doesn't know what the prices are. That's why he purchases the paper. The most valuable information that he might derive from this purchase is the information that surprises him. He might find that a stock that he owns has declined in value, and he might decide to sell it. Unlike the purchasing of a piece of machinery for his business, the value of information to this newspaper reader is related to the surprises that he experiences.

The economic literature on the value of information reflects the conceptual difficulties associated with thinking about how and why information acquires a value. Arrow (1971), following Shannon and Weaver (1949), suggested that the value of information can be captured by a measure of entropy. Entropy, however, is a measure of the unpredictability or the randomness of a system, and not the value of information about that system. Confounding of the value of and the demand for information on the one hand and the cost of and the supply of information on the other is commonplace in the theoretical literature.

3.3 Incentive Problems with the Production and Distribution of Information

Much of the literature on the economics on information has focused in the welfare and efficiency properties of market equilibria when market participants are less than completely informed about the relevant parameters of their economic environment. Several incentive problems involving the production and distribution of information have been examined. The *Free Rider* problem arises from the idea that, in many contexts, the costs of obtaining or producing information are high, relative to the costs of replication of that information. The information embodied in the

formula for a new pharmaceutical product may be costly, given the time and effort devoted to research and trials. But once that information is known, it can be copied quite easily. The free rider problem arises when individuals that have not contributed to the production of some information cannot be effectively excluded from the benefits of its use.

Information is sometimes seen as a *Public Good*. The technical definition of a public good, according to Samuelson (1954) is a good that is non-rival in consumption and for which it is difficult to exclude non-contributors. These two characteristics are conceptually separable. Non-rivalness means that once one person has consumed some of a good, there is no less of that good available for others to consume. For example, if a student memorizes one of Shakespear's sonnets, there are no fewer sonnets of Shakespeare available for others to memorize. The stock of Shakespearian sonnets available for memorization is a non-rival good. The books in which those sonnets are published, however, are not non-rival. If a student is reading a book of Shakespearian sonnets, then at that moment in time, there is one less book of Shakespearian sonnets available for someone else to read. Non-rivalness is a joint characteristic of a good and of the nature of the consumption activity related to that good. A good may be non-rival with respect to one type of consumption and rival with respect to another. For example, if the newspaper reader and his fellow readers in a city learn that the price of a particular stock has fallen, and that it is now undervalued, they might enjoy the anticipation of the wealth that they might gain if they acted on that information and that enjoyment could be non-rival. That is providing that none of them acted on the information that they have obtained and go out and buy the stock. A good like information may be non-rival in personal consumption but rival in commercial use.

Costly exclusion, the second attribute of a public good, is an artifact of the institutional environment in which decisions about that good are made, and the level of effort of technology applied to the problem of exclusion.
The incentive problem associated with public goods is like the children's story about the little red hen. Like the hen and her bread, people are reluctant to contribute to the provision of a public good if they think someone else will produce it, but once the bread is baked, everyone wants a slice!

Another class of incentive problems associated with the production and distribution of information relate to agency problems or transaction costs. These problems arise when participants in a transaction, such as a contract, a market exchange or some other relationship, cannot know if other parties to the transaction have done or will do what they have committed themselves to do, or if the information that they have provided is accurate and truthful. *Moral Hazard* arises when someone who is a party to a transaction acts in a more risky way than he would otherwise act because of the opportunity afforded in the transaction to shift the costs of bearing that risk onto other parties to the transaction. This problem has been of particular interest in the insurance literature, for obvious reasons, but it is a general problem in any transaction where the choices of parties to the transaction influence the overall level of risk associated with an activity.

Adverse Selection arises in markets where the goods or services exchanged, or the reliability of buyers or sellers in meeting their obligations, vary and where information about theses characteristics is scarce. Adverse selection is a version of Gresham's Law for imperfect information. In the limit, it leads to a situation where only the lowest quality goods and services

are offered for sale, because owners of high quality goods cannot obtain an adequate price premium[1].

Transaction costs were introduced to the economics literature by Coase (1937, 1960). Coase observed that participating in market exchange itself consumes resources. Use of the market is not costless. Dahlman (1979) developed a taxonomy of transaction costs that has seen widespread use. Person's seeking to enter into a market exchange or some other form of transaction incur three types of transaction costs. *Search Costs* are incurred in the process of finding a suitable party with whom to transact. The magnitude of the search costs involved in a transaction vary with the nature of the transaction itself. Finding someone who is willing and able to sell a litre of gasoline involves much lower search costs than finding someone who has a painting by Picasso for sale. *Negotiation Costs* are incurred is the process of determining the terms of the exchange. The more complex the negotiations leading up to a transaction, the greater this component of transaction costs. The final element in Dahlman's taxonomy is *Enforcement Costs*. Enforcement costs relate to the costs of monitoring and ensuring compliance with the terms of a transaction.

Demsetz (1969) has expressed a fundamental concern about the way in which economists have linked imperfect information with inefficiency. He describes the typical method of analysis as the "Nirvana Approach." This approach compares the performance of an actual institution or situation with the performance of an ideal hypothetical situation. Typically, the ideal hypothetical situation performs better. This result is used to diagnose a "Market Failure" with the actual institution or situation. For example, risk averse producers facing price risk can be shown to be willing to produce less than they would if they had perfect information about prices. At this lower level of production, price, or expected price, is not equal to marginal cost. This has been taken, in some circles, as indicative of inefficiency or market failure. But as Demsetz cogently argues, the use of an ideal, hypothetical but unattainable situation as a normative standard for the evaluation of actual existing situations leads to the conclusion that what exists is always sub-optimal. He recommends that economists investigating the efficiency and performance of existing markets, institutions and social arrangements should compare existing situations with feasible alternatives and not with unattainable ideal situations.

3.4 The Growth of the Transactions and Information Sector

The growth of the transaction and information sectors in most modern economies raises a number of important conceptual, definitional and practical issues for economic analysis. What has caused this growth? How do we measure or even define the information and transaction sectors? What is the output of the information and transaction sector? Can productivity be measured in these activities? Does growth in the relative size of this sector indicate a policy problem, or is it a natural phase in the evolution of a modern market economy?

Wallis and North have attempted to describe the growth and evolution of the transaction sector of the U.S. economy for the period 1870 to 1970. Given the close relationship between the production and distribution of information and transaction costs, their results are of interest to students of the economics of information. The Wallis and North study measures the share of aggregate economic activity devoted to transactions in the United States economy. This study breaks new ground in the definition and measurement of the size of the transaction sector. They

[1] See Ackerlof's The Market for Lemons

identify employment categories within firms that provide primarily transaction services. These categories included purchasing, distribution and management. The labour costs associated with these activities were considered to constitute transaction costs[2]. Wallis and North concluded that the transaction sector constituted about 25 % of GNP in the United States in 1870. This share had grown to 47 - 55 % by 1970. Growth in the relative size of the transaction sector proceeded at a relatively steady pace over this 100 year period. Wallis and North argue that growth in the transaction sector, most of which according to their definitions and data took place in the private sector during this period, are an expression of specialization and the gains from trade. This means that part of the apparent growth in the sector is a result of increased use of arms length relationships with providers of transaction services by firms that had previously conducted these activities in-house. This does not mean that Wallis and North suggest that there has not been any growth in the relative size of the transaction sector in the United States. They attribute the actual rate of growth to, first, the increased costs of specifying and enforcing contracts as the spatial extent of market transactions has grown within the United States economy, second, to technologically driven economies of scale in transaction services and third the use of the political process to redefine property rights. The latter creates a demand for transaction services both for those who expect to gain from reallocation of property rights and also for those who expect to lose.

Takaski and Ozawa (1983) have described the size of the information and transaction sector in Japan for the period 1960 to 1975. They found that the supply of information expanded more rapidly than the demand for information services in Japan during this time period. Jussawalla and Cheah (1983) developed an input-output model of the Singapore economy to study the contribution of the information sector to total value added in 1973. They concluded that 24 % of total value added in the Singapore economy was generated in the information and transaction sectors. Given the static structure of their model, they were not able to investigate trends in this sector. They did emphasize the importance of productivity gains in the information and transaction sector to future employment and income prospects in Singapore.

3.5 The Value of Information - A Conceptual Framework

Information acquires value because it helps people take more effective actions toward the achievement of their goals. The value of information is inseparable from choice under risk, risk aversion, perceptions and expectations. The value of information is related to subjective states of mind of the people that receive it. Advances in information technology reduce the cost of information relative to its value in production or marketing. Improvements in information technology enable organizations to economize on transaction costs (Coase, 1937, 1960), that is the costs associated with conducting exchanges in the external relationships of the organization, and on coordination costs, that is those arising in the internal relationships of the organization.

Frank Knight (1921) introduced the distinction between risk and uncertainty. Both risk and uncertainty are terms used to describe contexts in which choices are being made in which people do not have perfect knowledge about all of the consequences of their actions. *Risk* refers to a situation where a decision maker knows the relevant dimensions of the choice problem, such as the ends sought and the means available, and the imperfect knowledge is limited to specific parameters of the relationships between ends and means. The probability

[2] That is, capital and other non-labour input costs were not included.

distribution of the imperfectly known parameter can be characterized objectively. For example, consider the simple case of flipping a fair coin. The decision maker's choice is to call heads or tails. The desired end is to make a correct call. The probability of a head and of a tail is known objectively, as is the level of risk, that is that variance of the expected outcome.

Uncertainty occurs when the relevant dimensions of the choice problem are not known and the probability distribution of the relevant random variables that are parameters of the choice problem cannot be characterized objectively. In this context, the decision maker may not know all of the ends to be advanced or may not fully appreciate the productivity of the means at his disposal. It is sometimes said that risk is insurable or poolable, whereas uncertainty is not. But it is more helpful to think of a continuum of cases proceeding from simple instances like the coin flipping case at one end and proceeding through situations in which less and less objective agreement on the structure of the decision problem is known. The premia that must be paid to off-load the cost or disutility of dealing with the increasingly imperfect knowledge rises as one proceed along this continuum.

Information and information technology can contribute value to an organization by clarifying the dimensions of choice problems, by compiling available data to characterize the probability distributions of relevant stochastic elements of a decision and by transforming uncertainty into risk. Knight's distinction between risk and uncertainty is not frequently invoked in the contemporary economics of information literature. In effect, virtually all of this literature treats decision making under imperfect information as though it were choice under risk.

3.6 Characteristics of the Production and Distribution of Information

Strassmann (Berger et al, Chapter 2) lists four characteristic problems associated with the production and distribution of information. Tangible goods usually diminish in value with use, but the value on information increases with use[3]. Labour productivity usually increases with the volume of production in the production of conventional goods, but increasing the amount of data tends to decrease the productivity of information workers. The marginal cost of replication of information is usually much lower than the cost of obtaining the original. Neither the value of information nor its price necessarily is equal to its marginal cost.

3.7 Types of Information Value

Ahituv (1980) identified three senses in which information might be thought to be valuable in an organization. The *Perceived Value* of information is the amount that a decision maker would bid to obtain information with some specified content. For example, a gambler might be willing to pay for private access to accurate information on the outcome of tomorrow's horse race. In an early example of experimental economics, Green et al (1967) conducted a study of what Sales and Marketing Executives and graduate business students would be willing to pay for market research survey information. The experiments were conducted as a series of simulation games. One game was used to study the value of error-free information. A second was used to investigate the value of partially reliable information. The third explored the value of survey information as a function of its reliability and cost, and the fourth investigated the value of survey information with two-staged sampling. The general finding of this research is that the participants in the experiments responded that they were willing to bid more for the various types

[3] Hirshleifer (1971) shows that the aggregate value of information does not necessarily increase with increased dispersion of information.

of information than the experimenters calculations of expected utility indicated were warranted. Economists and agricultural economists have undertaken a modest number of studies to estimate this type of willingness to pay value of information.

Revealed Value is the difference in actual performance of an organization with and without access to a particular source of information. Estimation of revealed value requires the ability to expose similar organizations to different information environments, or the same organization to different information environments in time periods that are similar in other substantive ways. *Normative Value* is the difference in optimal performance by an organization under different conditions of access to information. Normative value is an upper bound calculation for the value of information to an organization. Most efforts by economists and agricultural economists to characterize and to estimate the value of information within the firm have focused on the this idea of the normative value of information.

Three measures of normative information value have appeared in the literature[4]. The first measure characterizes the value of information as a change in expected utility. Specifically, where

$$V_1 = E^m U(w(x,s)) - E^l U(w(x,s))$$

V_1 is the value of information
E^m denotes the expectation operator for the "more informed" state
$U(\,)$ is the decision maker's utility function
$w(\,)$ is the level of wealth, that depends on
s, the state of nature that occurs and
x, the action that the decision maker takes.
E^l is the expectation operator under the "less informed" state

That is, with the level or type of information that the decision maker would use to choose what to do if the information system whose value is being studied were not available.

The second and third definitions of information value are monetary. The second definition, V_2, is

$$E^m U(w(x,s) - V_2) = E^l U(w(x,s))$$

This is the maximum amount that a decision maker would be willing to pay to gain access to an information system and be no better and no worse off than he expects to be without that access. The third definition, V_3, is

$$E^m U(w(x,s)) = E^l U(w(x,s) + V_3)$$

[4] These definitions are based on Hilton (1981), although the notation has been simplified.

which is the minimum amount that the decision maker would be willing to take in exchange for losing access to an information system currently in use.

3.8 The Value of Information - Some Illustrative Examples

Visualization of the nature of the value of information as an input in production and marketing is difficult. The value of information technology and the value of information in production and marketing are closely related. The following simple examples illustrate how information can acquire a value to a farm firm. These examples clarify some of the conceptual and empirical problems associated with the evaluation of information and of information technology in agriculture.

3.8.1 Price and Yield Response in Corn Production

Information about the price that will be received at harvest can help a producer choose a more appropriate level of input application. Consider the case of nitrogen application on corn. Using a quadratic yield response function for the response of corn to nitrogen fertilizer,

$$Yield(N) = 50 + 0.5N - 0.001N^2$$

where yield is expressed in bushels/hectare and nitrogen application is measured in kg/ha. The Value of the Marginal Physical Product of nitrogen, VMPP(N), is a linear function,

$$VMPP(N) = p(0.5 - 0.002N)$$

Where p is the price of grain corn in $/bu. The yield response function and the relationship between gross revenue per hectare and nitrogen costs per hectare are illustrated in Figures 1 and 2. A corn price of $ 2.75/bu and a nitrogen price of $ 0.85/kg were used to draw Figure 2. If the producer's goal is to maximize net returns per hectare to the application of nitrogen, then the level of N should be chosen that maximizes the difference between the Revenue(.) and Cost (.) functions in Figure 2. Net returns per hectare can be drawn as a function of the level of Nitrogen application by subtracting the Cost(.) relationship from the Revenue(.)relationship. This is illustrated in Figure 3.

Net returns to the application of nitrogen are highest when the curve labelled Net(.) reaches a peak. For a corn price of $ 2.75 and a nitrogen price of $ 0.85, this occurs at a rate of 95.46 kg/ha.

For this regime of prices, the value of the marginal product of nitrogen application equals marginal factor cost at 95.46 kg/ha. But suppose that the actual price of corn at harvest turns out to be $ 4.25/bu. If the producer had known that this was going to be the price at harvest, then he would have been facing a different Value of Marginal Physical Product function. Figure 4 shows that this higher price shifts and rotates the VMPP function. If the farmer could have know that the price of corn was going to be $ 4.25, he would have liked to apply 150.00 kg/ha of nitrogen. This is where the peak of the net returns function occurs under this higher price. (See figure 5) The actual relationship between nitrogen application and net returns, drawn as the

dotted line in Figure 5, shows that net returns increase up to 150.00 kg/ha. At this level of nitrogen use, net returns are $ 308.13/ha. If the farmer acts on his (mistaken) belief that the price of corn is only going to be $ 2.75/bu, he will apply 95.46 kg/ha. He expects to receive net returns of $ 162.56/ha, but he will actually receive $ 295.48/ha. Figure 6 illustrates what the producer could have earned if he had known what the corn price was going to be before he applied his nitrogen, and it shows what net returns he actually receives from applying what turned out to be the "wrong" amount of fertilizer, ex post. The difference between the net returns the farmer could have earned if he had known that the price of corn was going to be $ 4.25/bu, and the net returns that he actually receives having acted on the belief that the price was only going to be $2.75/bu is the value of correct price information for this farmer. This difference is represented by the vertical difference between the solid and the dotted horizontal lines in Figure 6. In the example being considered, this amounts to $ 12.65/ha. This is the maximum that this farmer could have paid to know that the price of corn was actually going to be $ 4.25/bu and be no worse off, in terms of net returns per hectare, then he would be if he acted on his incorrect information that the price of corn was going to be $ 2.75/bu.

This is an admittedly simple example, but it illustrates several important aspects of the value of information. Information has value if it enables people to make better choices about the way that they use the means at their disposal to achieve the goals that they seek. The greater the difference between what people expect to happen and what actually happens as result of the actions that they select, the greater the potential value of information.

Figure 1: Corn Yield Response to Nitrogen

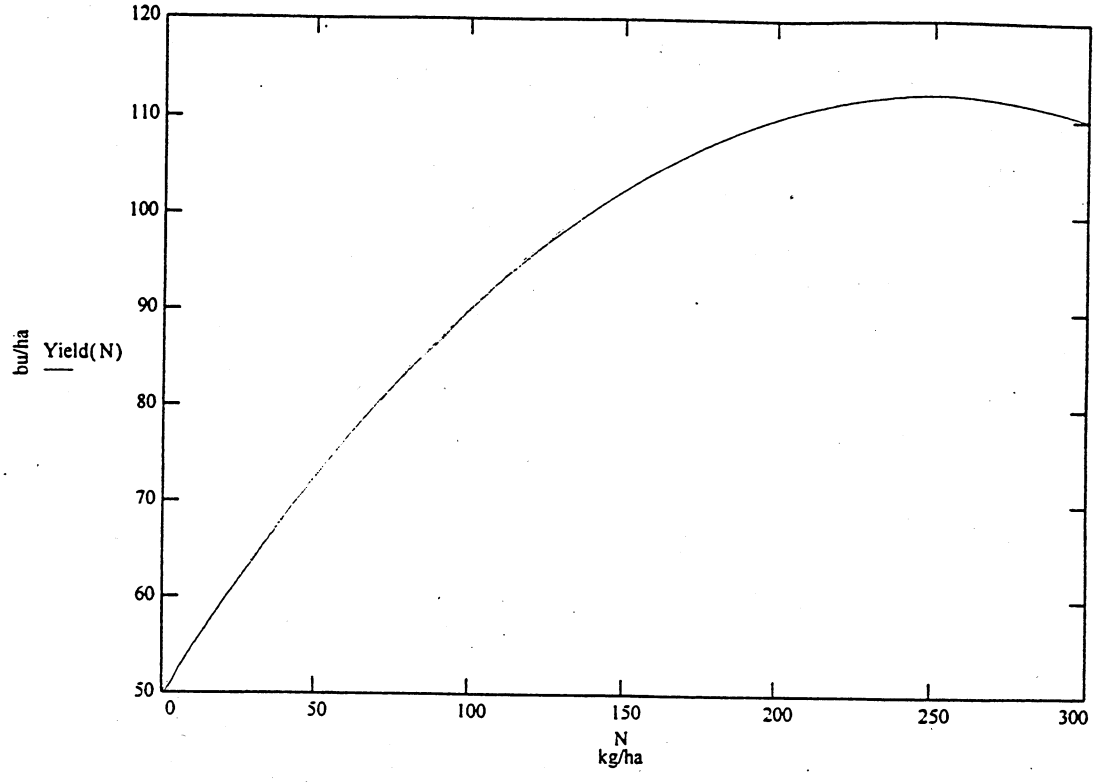


Figure 2: Gross Revenue and Nitrogen Costs per Hectare

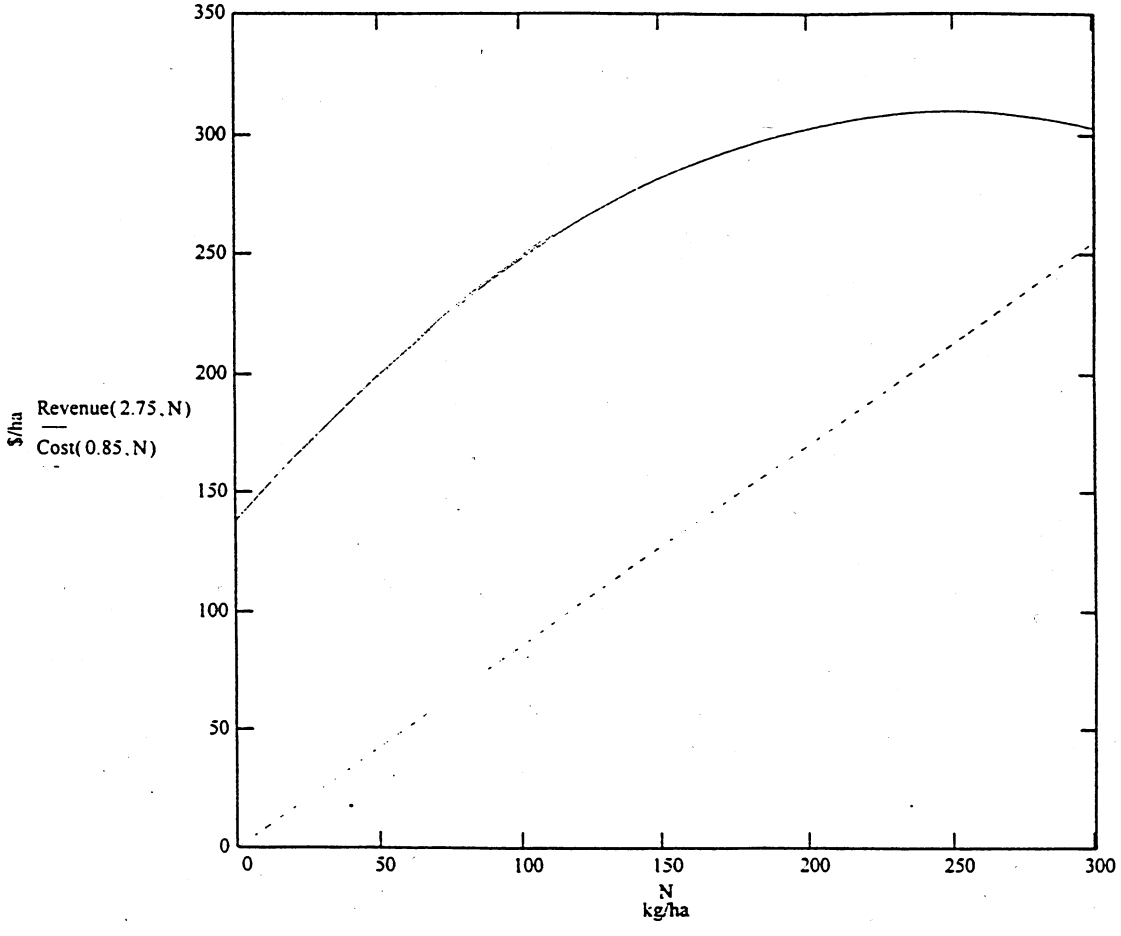


Figure 3: Net Returns to the Application of Nitrogen

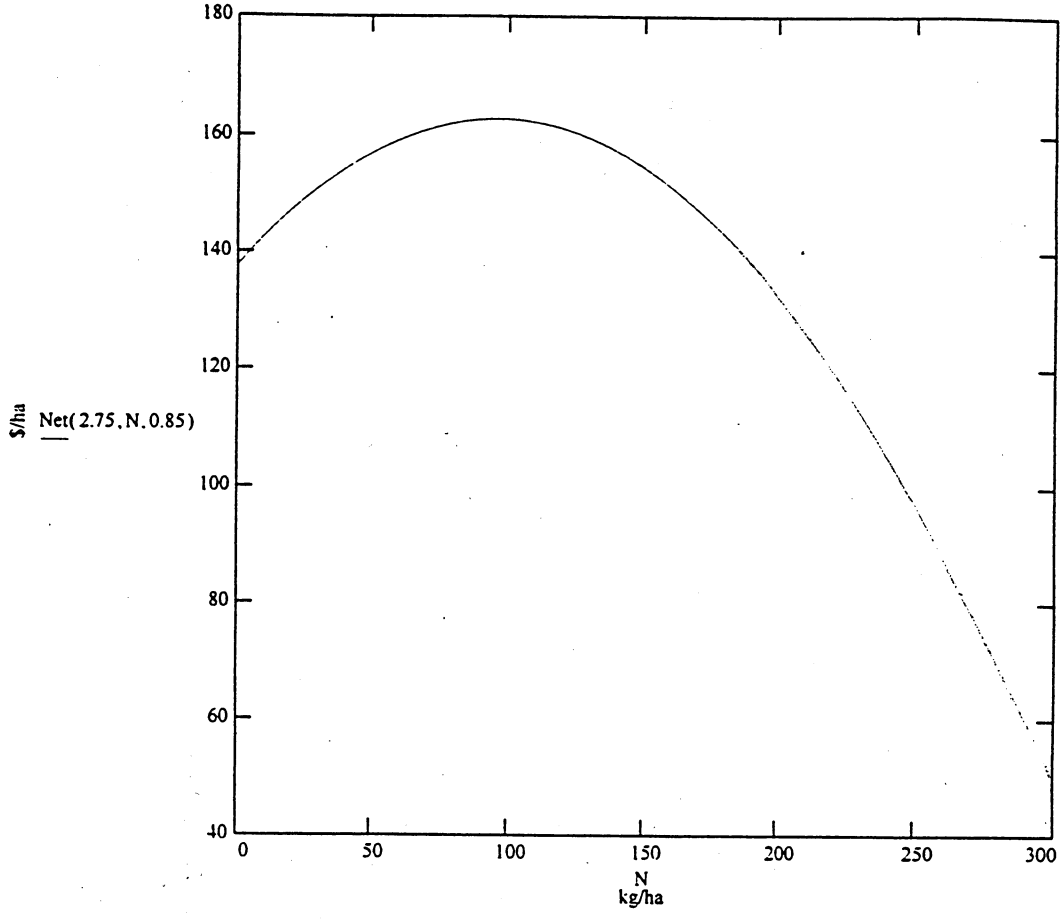


Figure 4: The Value of the Marginal Physical Product of Nitrogen Application

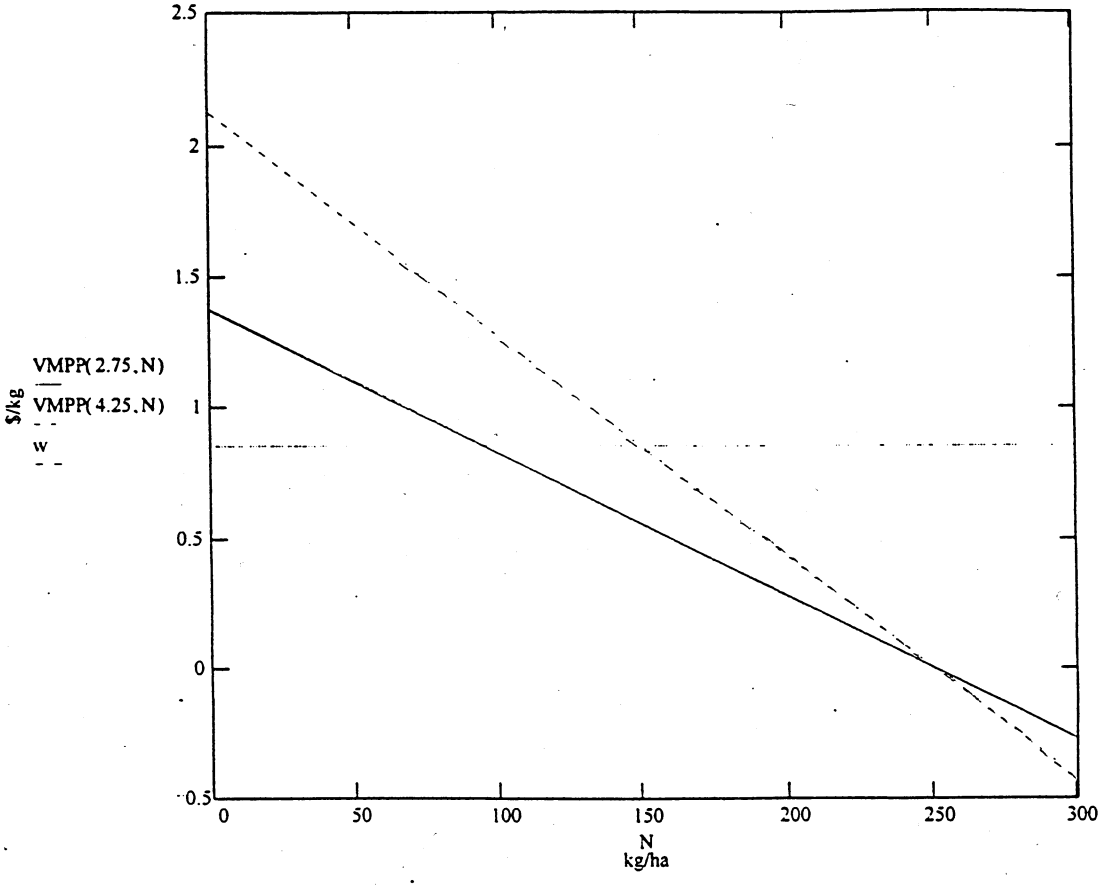


Figure 5: Net Returns per Hectare for Two Corn Price Regimes

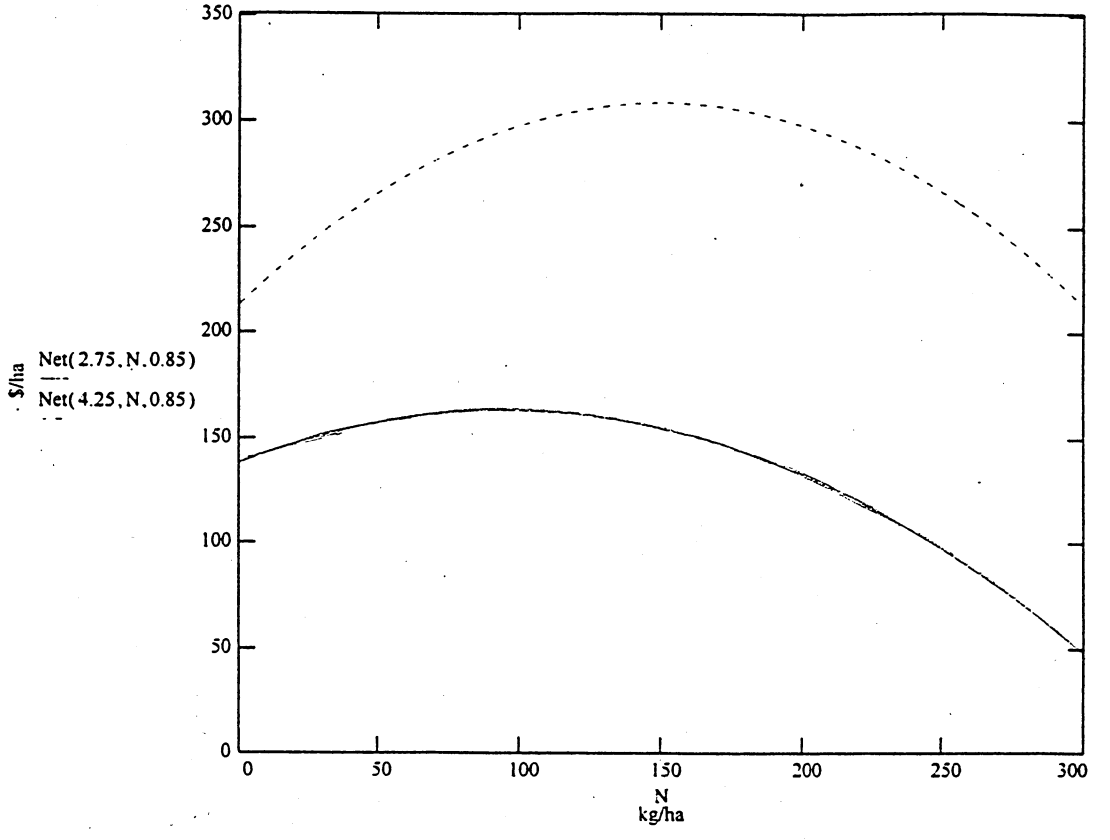
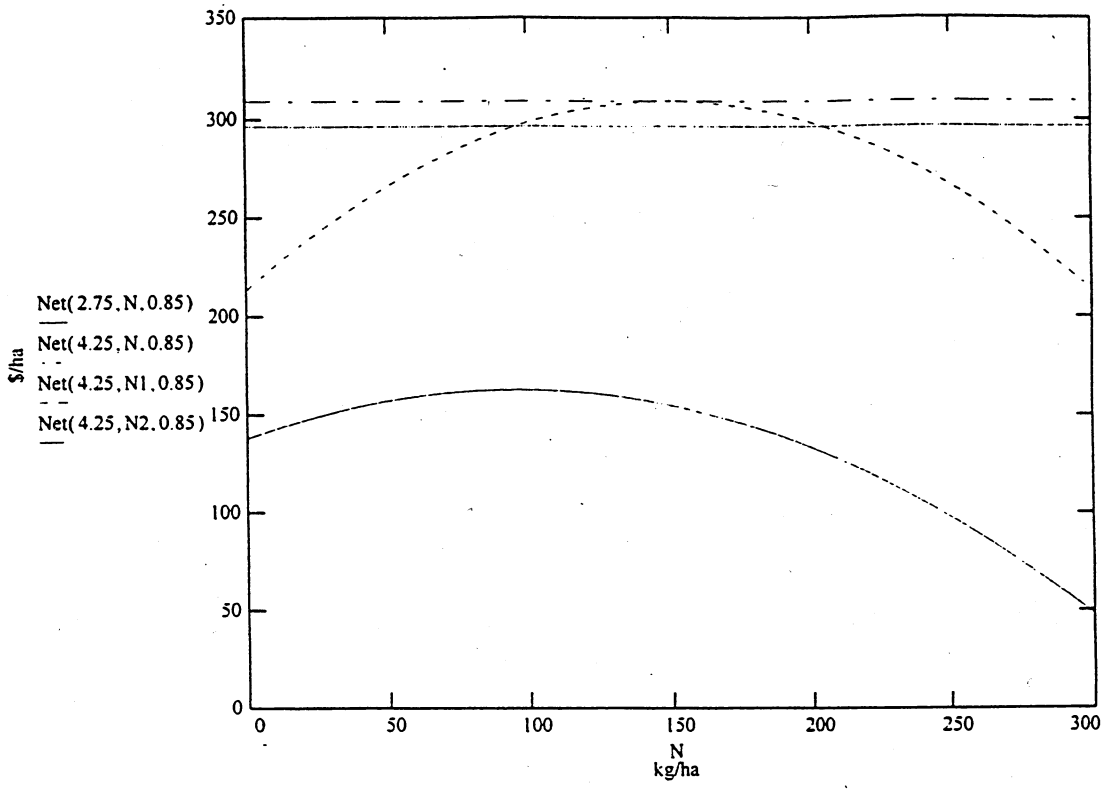


Figure 6: The Value of Price Information



3.8.2 The Value of Price Information Under Risk Aversion

The example above illustrates how information can acquire value in production, but it is somewhat unusual to think about a value for information in a situation where risk preferences don't matter. Suppose that a risk averse farmer is uncertain about the price that he will receive for his corn crop. The expected utility model has been used extensively to study the behaviour of risk averse behaviour of farm firms. This model assumes that farmers choose production plans under risk so as to maximize the expected utility of, typically, profit. The Certainty Equivalent Profit model[5] is a special case of the more general Expected Utility Maximization model[6]. The Certainty Equivalent Profit model assumes that a producer will choose a production plan that maximizes expected profit less a risk premium. The Risk Premium, R( ), is evaluated as
where π is profit and γ is the Arrow-Pratt coefficient of absolute risk aversion. The certainty

$$R(\pi)=(\gamma/2)\,Variance(\pi)$$

equivalent profit is the level of riskless profit that would give a risk averse decision maker the same level of well-being as the expected utility of a risky outcome.

Using similar data to the previous example, suppose that a farmer is selecting the level of nitrogen fertilizer to apply to his corn crop before he knows what the price of grain corn at harvest is going to be. Yield response follows the relationship used in the previous example. The unit cost of nitrogen is $ 0.85/kg. The farmer believes that the price of corn is a normally distributed random variable with an expected value of $ 2.75/bu and a variance of 10.00. His Arrow-Pratt coefficient of absolute risk aversion is 0.0001. Under these circumstances, his per hectare certainty equivalent profit for nitrogen application is

$$C.E.P.=E(\pi)-\gamma/2((Yield)^2\sigma^2$$

$E(\pi)$ is expected net returns per hectare from the application of nitrogen. γ is the Arrow-Pratt coefficient of absolute risk aversion and σ^2 is the variance of the price of grain corn. Yield is a function of the level of N applied. Figure 7 illustrates the relationship between the per hectare certainty equivalent profit and the level of nitrogen application based on the farmer's beliefs about the distribution of the price of grain corn. If he acts on this belief, he will apply 90.37 kg/ha of N, since this maximizes his per hectare certainty equivalent profit.

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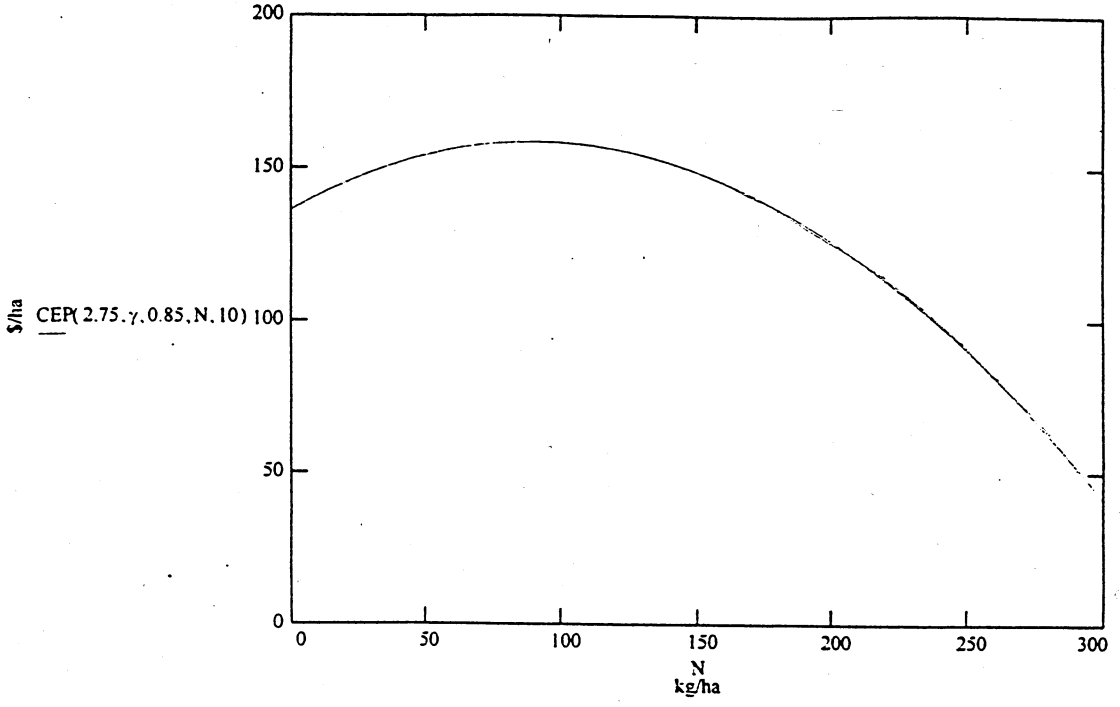
[5] See Robison and Barry (1987) for a detailed exposition of this model.

[6] The Certainty Equivalent Profit model is a special case of the Expected Utility model for utility functions exhibiting constant absolute risk aversion and normally distributed risks.

Figure 7: Certainty Equivalent Profit and Nitrogen Application



Suppose that the actual distribution of the price of corn has a mean of $ 4.25/bu with a variance of 10.00. This means that the true relationship between nitrogen application and certainty equivalent profit per hectare is as indicated by the dotted function in Figure 8. Maximum certainty equivalent profit per hectare occurs at a rate of nitrogen application of 147.54kg/ha in this case. A farmer that applies 90.37 kg/ha, based on his mistaken beliefs about the nature of the distribution of the price of corn would realize a certainty equivalent profit of $ 289.23/ha. If he had known the true distribution of the price of corn, he could achieve a certainty equivalent profit per hectare of $ 302.90. The most that he could pay for information about the true distribution of the price of corn is the difference between these values, or $ 13.67/ha. If he had to pay this amount to learn about the true price distribution, he would be indifferent between acquiring this information and acting on his prior but incorrect beliefs.

3.9 The Value Of Information In Agriculture

3.9.1 Sources of Information Used by Farmers

Farmers appear to obtain information from a mix of popular and trade media, and personal communication. Cameron (1975) reported that 97% of the Ontario beef farmers surveyed cited radio as the most used source of market information, followed closely by beef sales people. Print media was also used to obtain production information, with 85% and 83% citing weekly periodicals and magazines, respectively. Blackburn et al (1983) found similar results among a random sample of Ontario farmers, but reported that "farm leaders" reported personal experience and contacts as higher ranked sources of information. This difference in how sources of information are ranked was also reported by Howard, Brinkman and Lambert (1994). "Top" managers reported personal networks and contacts as more important sources of information than did "average" managers, who relied more on television and newspapers as their primary sources of information.

3.9.2 Price and Marketing Information

Government price and quantity forecasts are common examples of public information, and as such, the value and accuracy of information they provide has been evaluated in several studies. In particular, the accuracy of USDA forecasts have been compared to futures prices, and the reaction of futures markets to USDA announcements have been evaluated in order to provide some benefit/cost measure of publicly funded information. While most of the studies report that USDA forecasts are unbiased and consistent with futures market prices, there does not appear to be a consensus on the value of publicly funded price forecasts.

Given that a market clearing equilibrium price is Pareto optimal, any other price will have a dead-weight loss and associated public welfare loss. Hence, information which increases the speed at which a market clearing equilibrium price is discovered benefits producers, consumers and society as a whole (Freebairn 1976, Stein 1992). Studies have estimated the value of increased accuracy of forecast information to be very high (Antonowitz and Roe 1986, Bradford and Kelejian 1978, Hayami and Peterson 1972). However, several studies have also reported no significant difference between USDA price forecasts and futures prices, and that there is little evidence that futures market prices react to USDA reports (Colling and Irwin 1990, Colling, Irwin and Zalauf 1996, Irwin, Gerlow and Liu 1994, Patterson and Brorsen 1993). The question remains: if there is no significant difference between USDA forecast prices and futures market prices, why are public funds spent on USDA forecasts?

Figure 8: Certainty Equivalent Profit and Nitrogen Application

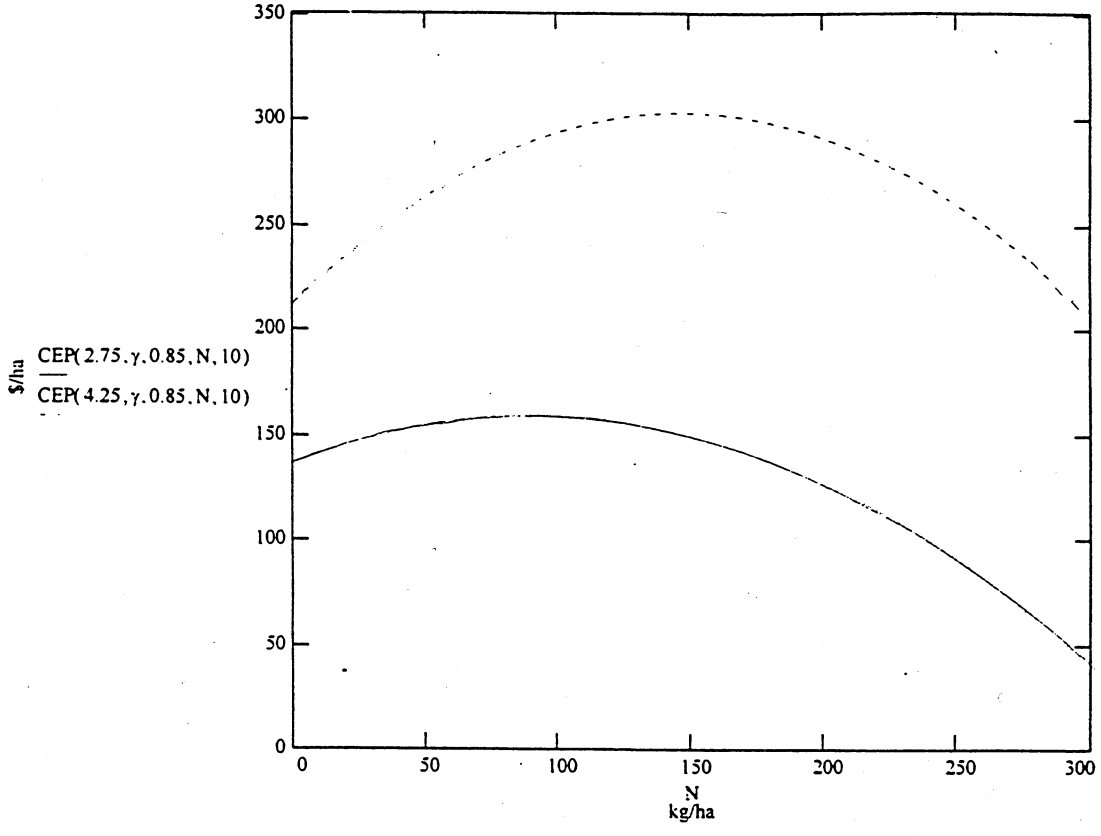
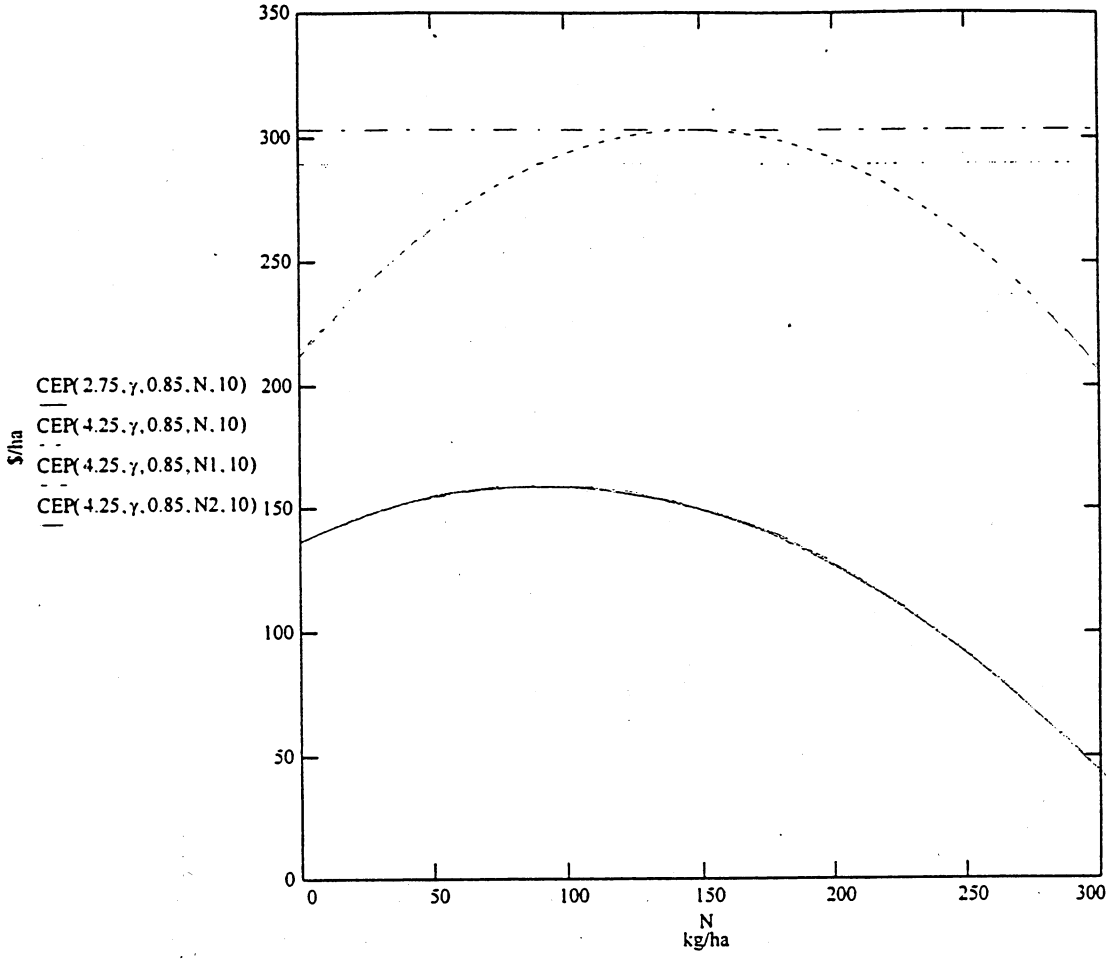


Figure 9: The Value of Price Information Under Risk



Three plausible explanations have been presented. First is that while futures markets are necessary for efficient price discovery, they are not sufficient (Stein 1992). Second is that information has externalities. If a trader has private information that he/she will not act upon for fear of giving competitors insight about their private information, then society looses because a net social welfare gain could have been realized if that private information had been public. Third is that speculators may over invest in information gathering activities, even though in the long-run is a zero-sum game, with no gain for society and a loss from resources spent on gathering information for the speculator (Hirshleifer and Riley 1992).

3.10 Weather Forecast and Production Risk Information

The value of weather information is a subdivision of the economic literature on the value of information. The purpose of this section is to assess methods used to determine the value of weather forecast information used in agricultural production. The literature reveals two methods that have been used in the valuation of weather forecast information. The first category of models can be described as being descriptive. The other category is composed of studies that are prescriptive (Murphy, 1994). Both methods have been used in the valuation of weather information. Both models have attributes which make them effective in the determination of the value of weather forecast information.

3.10.1 Descriptive Models

Descriptive models focus on understanding how decision-makers actually use information and make decisions (Stewart et al., 1984). Many descriptive studies have relied on surveys or interviews to provide the information needed to develop forecast value estimates (Murphy, 1994). Carlson (1989) used a descriptive approach to determine weather information needs of the agricultural community in Michigan. Surveys were distributed to a representative cross section of producers of field crops, livestock, fruit, vegetables and timber. Farmers were asked to estimate the yearly monetary value of weather information to their operation. 6% of respondents indicated that the value was up to $100/farm/year, 23% between $101 and $1000/farm/year, 53% between $1001 and $10 000/farm/year and 18% over $10 000/farm/year. The survey also determined how and if weather information was being used by farmers. Questions pertaining to activities in which weather information is used and the type of information used yielded this information.

Vining et al. (1984), in a survey of Texas farmers, asked farmers to rank information type on a scale of importance and their preference for obtaining information. They were also asked what they would be willing to pay for current quality weather forecasts. The farmers had a mean willingness-to-pay of $484 per year per farm. The authors concluded that the willingness-to-pay values cannot be interpreted as economic values, or marginal values, as would be indicated by a competitive market price.

Warren and Leduc (1982) assessed the value of meteorological information contained in a report containing weather information pertinent to food production. Respondents were asked to state the cost of substitute weather forecast information, the willingness to pay for direct line access to weather information and willingness to pay for the current information. Respondents indicated that the cost of substitute data would be $12 184 per year per firm. They would be willing to pay $500 to $2000 per year for direct line access to the data. The mean willingness to pay for the current information was only $436 per year. The researchers appear to have hoped that the answers to each question would be similar to each other. Asking the appropriate

question to obtain the true value of weather information is an important and difficult task in developing a survey. This appears to be a major weakness when using surveys to determine the value of information.

Stutchbury (1980) was interested in seeking ways to improve meteorological services to farmers in Southern Ontario. The study determined how information was used in the decision making process by farmers. It also determined what information was being used in the decision making process. The study determined how farmers obtain information using survey questions. It was found that farmers use public radio, television, automatic phone answering machines, weather radios, the weather office and their neighbour as sources of weather information. Farmers were asked if they would be willing to pay $120 for a weather radio receiver. The majority of farmers said they would not pay this amount on a weather radio.

Stewart et al (1984) studied how orchardists make frost protection decisions in the Yakima Valley of Central Washington. Growers were asked to describe their frost protection practices and the methods used to determine when to protect their crops. It was found that the frost protection process varied little among growers. Although the research did not conclude with a value of information, it did provide information required to place a value on weather information. The study determined how, when and if weather information is used in a farmers decision process. This is the first step in understanding how weather forecast information is valuable. The survey or descriptive method is effective for this purpose.

Research using the survey method has seen limited success in estimating the value of weather forecast information for farms. Another problem that arises when using surveys, outlined by Warren and Leduc (1982), is obtaining a sample size which is sufficiently large. An advantage of the descriptive method is the ability to determine what information is used and how it is used in the farmer decision process. It appears that the descriptive method cannot be used alone to determine the value of weather information.

3.10.2 Prescriptive Methods

Prescriptive analyses focus on the impact of weather information on optimal decisions and economic welfare (Gandin et al., 1992). This method has been used more frequently than the descriptive method in the estimation of the value of weather information for farms. The most popular form of model appears to be farm level optimization models. These models maximize profits, expected income or expected utility. Other models attempt to value weather information at the market level, taking into consideration any impacts weather information may have on the price of the commodity or inputs in the production process.

3.10.3 Expected Profit Models

Wilks (1992) developed a model calculating the economically optimal cutting strategy for alfalfa grown in Central New York. Probability of precipitation and mean daily temperature data are incorporated in the model. Alfalfa growth is simulated over an entire growing season. The model assesses weather information and decides whether to cut or not. Simulations were conducted using various methods of weather forecasting and different forage preservation techniques. The value of weather forecast information was found to be $84/ha/year for wilted silage and $106/ha/year for hay.

A simulation model was used to assess the benefits of using climatic data and available weather services in corn irrigation decisions for the 1938-1967 growing seasons in Central Missouri (Hashemi and Decker, 1969). Four irrigation decision techniques were compared. One method involved using probability of precipitation forecasts for given amounts of precipitation to determine when and how much to irrigate. This method decreased the frequency of irrigation over the corn growing season when compared to using other, less scientific methods. The paper did not calculate a value for forecast information. A value could be calculated as the difference between yield loss when using and not using irrigation. Simulation models require large amounts of data to effectively simulate the growth of a crop. If the data is available then this approach can be very useful in the determination of the value of weather information to agricultural producers.

Tice and Clouser (1982) used multiple regression to estimate corn yield response functions to nitrogen. Weather variables were included as regressors. A soybean yield model was also estimated to indicate how weather conditions affect production. The model selected optimal land allocation for weather scenarios describing "bad", "average" and "good" conditions for West Central Indiana. Data was obtained for the period 1967-1977 from the Purdue University Agronomy Station. Results indicated that net farm incomes could be increased by 9% to 14% through the use of weather forecast information.

The value of weather information to California raisin growers was studied by Lave (1963). A farm level supply curve for producers was developed using least squares regression. A weather variable for growing degree days is included in the equation and plays a significant role in the determination of raisin supply. A game tree was developed detailing possible harvest actions in a sequential approach. Expected values are assigned to each grower action. A comparison of expected values with and without information yields a value of $90.95/acre/year.

3.10.4 Expected Utility Models

An advantage of optimization models is the ability to incorporate the sequential decision making process involved in agricultural production. However, the models discussed thus far incorporate expected profit as the goal of the producer. It is questionable that farmers behave in such a manner. It is important to incorporate as much of how the farmer actually uses the information as opposed to how he should use the information in the valuation of weather information.

Studies into the value of information have attempted to better describe the goals of producers by using an expected utility maximization approach. Baquet et al. (1976) used a simulation model to provide estimates of the economic value of frost forecast information to pear producers in Oregon. The farm operator was assumed to maximize expected utility. Utility functions were derived for eight orchardists using the Ramsey method. Values of information were obtained for various assumptions regarding forecast information and operator goals. The value of frost forecast information was found to range from $4.73/acre/day to $8.57/acre/day.

3.10.5 Market Level Models

An advantage of using optimization models incorporating farmers risk attitudes is that they can demonstrate that each farmer has different risk preferences and will therefore use weather forecast information differently in making production decisions. A disadvantage of optimization models with risk is that it is difficult to quantify risk attitudes of individuals. Farm level models in general do not capture price impacts that may occur at the market level. As producers use

weather forecasts to increase the production of their commodities it is possible that the price of the commodity will be negatively affected.

Lave (1963) extended the firm level valuation to estimate a value of weather information to the California raisin industry. He reasons that weather information allows bigger and better crops to be produced which can have a significant impact on commodity prices. A market demand curve was developed using ordinary least squares regression. Elasticity of the demand curve at the mean was found to be 0.448. Industry profits will fall when supply increases. It was concluded that better weather information will have a negative value to the raisin industry. It was estimated that an increase in industry supply of 10 000 tons would reduce industry profits by at least $600 000.

Babcock (1990) developed a theoretical market level model illustrating the effects of weather information at an aggregate level. The model illustrates that when demand is elastic the marginal value of information increases with an increase in forecast accuracy. When demand is inelastic, the marginal value is negative. If the industry supply curve is inelastic then an expansion in supply will result in lower profits in the case of an inelastic demand. Babcock suggests that when farmers realize that weather information will increase production and decrease prices such that profits decline then the farmer will produce less. Therefore, weather information can be a supply decreasing production input.

Market level valuation allows the entire impact of the information to be examined. Farm level valuation could prove meaningless if there are significant price effects at the market level. However, it is important to determine if the market is affected in such a way before carrying out such a study.

3.10.6 Synopsis

Several approaches have been used in the valuation of weather information. Each method has its own strengths and weaknesses. There is not a perfect methodology to be used in the estimation of the value of weather information in agricultural production. It appears that the strengths of the prescriptive and descriptive methods should be combined into one method to develop a stronger framework for the valuation of weather information.

Descriptive studies have had limited success estimating empirical values for weather forecast information. These studies have been successful in determining how weather information is used in the production of various commodities. Prescriptive studies have been more successful in placing a value on weather forecast information. However, these studies tend to focus on how farmers should use weather information to achieve a goal as opposed to determining how farmers actually use weather forecast information.

3.11 Other Types of Information and General Policy Issues

It is obvious that accurate information is more valuable than inaccurate information, and that inaccurate information will decrease the credibility of an information source. For many years agricultural extension agents have been a source of information about new technologies and production and management practices, but several studies have raised questions about the accuracy of the information from extension agents, and hence the perceived value of the information they disseminate.

A study of the up-take of mastitis control practices on Texas dairy farms reported that farmers and "experts" had similar expectations about the effects of various management practices, but that extension agents' beliefs were different than either the farmers' or the "experts'" beliefs (Howard et al 1987). Inaccurate information from extension agents is also evidenced in that most "top" managers by-pass extension agents and go directly to the "experts" (Howard, Brinkman and Lambert 1994).

3.12 The Value of Information Technology -- General

3.12.1 Information Technology

According to Mukhopadhyay (1988, p.2),

An MIS [Management Information System] is an integrated user-machine system that provides information to support one or more decision making functions in an organization (Davis and Olson, 1985, p.6). It utilizes computer hardware and software, data and models, people (eg. systems analysts, programmers, computer operators, etc.) and manual procedures. Typical examples of MIS include sales forecasting and analysis, and production and inventory control systems.

An MIS should be distinguished from an organizational information system. Typically an organizational information system is a confederation of many interrelated management systems (Senn, 1978, Nuemann, 1980). That is, an MIS is a part of an organizational information system, and may have varying degrees of linkages with other MIS in the organization.

Information technology permeates every aspect of our lives. It has changed the way organizations co-ordinate individuals and social groups. New co-ordination possibilities of information and communication activities offered by information technology affects the production, distribution, and consumption of goods and services that constitute societal wealth. Information technology is a vehicle for greater political participation, more leisure, greater equality between the sexes and classes, more freedom, and more choice.

Information technology can be viewed as a compilation of machines. These machines include computers, telephones, word processors, robots, satellites, automated bank tellers, cable television, and so on. In broad terms, there are two types of machines that make up information technology: computers and telecommunications. The distinction between computers and telecommunications has blurred so that their progress is described as convergent (Locksley, 1986). Computers are used not only for information processing but also for communication. Sophisticated telecommunications equipment requires computers for their operation. In addition, an increasing among of information transmitted through telecommunications equipment is sent and received via computer.

Information technology acquires value in the production of goods and services in two ways. First, it reduces the cost of transactions that take place within firms and between firms. Magnetic tapes, disks, and memory chips have replaced paper files; computers have replaced filing cabinets; and typed memos have given way to electronic mail messages. Second, information technology increases the efficiency of the other factors of production, labour and capital. Highly recognized benefits of information technology include better record keeping, more timely and accurate and expanded information, and improved customer services (Tye and Chau, 1994).

However, the level of information technology does not directly relate to management productivity. Firms that use large amounts of information technology do not necessarily deliver results that are superior to firms that use lesser levels of information technology (Tye and Chau, 1994). Because firms spend a substantial proportion of their budgets on information technologies, managers need to know the full value of this major expenditure. Information technology evaluation suffers from scarce and scattered theoretical background and therefore it is difficult to decide on what exactly is to be measured.

3.12.2 Approaches to the Evalution of Information Technology

Mukhopadhyay (1988) describes six general approaches that have been used to evaluate information technology in organizations. The *Computer System Approach* uses computer simulation software to evaluate the system performance of a management information system. Performance criteria are defined for various aspects of the management information system. Evaluations of this type emphasize things like percent uptime, system throughput, response times, error rates and turnaround times. *Cost-Benefit Analysis* or capital budgeting uses estimates of costs and benefits associated with the installation and use of a management information system. Information technology that reduces costs, through, for example savings in clerical labour costs are typically easier to assess with cost-benefit analysis than information technologies that enhance organizational performance. The benefits of information technology have proven to be more difficult to quantify than costs or cost savings.

The *Systems Usage Approach*, in the absence suitable measures of the benefits of information technology, uses data on system utilization as an indicator of performance. These measures would include things like frequency of use, time per session and number and volume of reports produced by the system. The *User-Oriented Approach* is similar to what Ahituv called the perceived value of information. User satisfaction measures are based on willingness to pay and related survey type evaluations. The *Multi-Attribute Utility Approach* proposed by Ahituv (1980) is based on an additive utility function for the attributes of Timeliness, Content and Format. This approach requires the calibration of utility sub-functions for each attribute for either an individual decision maker or for an organization. The sixth approach, and the one that Mukhopadhyay uses in his empirical work, is called the *Economic Production Analysis Approach*. This method of assessment treats information technology as an input to the production function of an organization. The benefits of information technology are measured as gains in productivity in input use by the organization.

3.13 The Impact and Value of Information Technology in Agriculture

3.13.1 On Farm Adoption and Use of Computers

The adoption and use of computers on the farm appears to have followed the pattern of adoption that Griliches identified for hybrid corn (Griliches 1957). A few of the younger, better educated, wealthier risk takers try the new technology as "early adopters", who are then followed by the "middle adopters" once the benefits of the new technology have been clearly identified, and lastly, the "late adopters" may or may not finally adopt the new technology. This "S-curve" of rate of adoption has been identified for most new technologies and practices (Rodgers 1983).

The advent of the mini or personal computer in the early 1980's prompted farm management researchers to study computer use on the farm: percent of farms using computers, who used them, and what for. Table 1 lists several studies from this period. Two common themes emerge

from these studies. First is that adoption of computers on the farm has been slow, with most recent studies estimating that about a third of all farmers use computers. Second is that farmers who use computers are likely to be younger, more educated, and have larger operations and higher incomes than non-computer using farmers. Age alone does not differentiate early and late adopters of new technologies, but all the studies that included age as an independent variable to explain use/non-use of computers found age to be significant. Similarly, size alone does not differentiate use/non-use, but size is an indicator of complexity and number of transaction needed to be recorded. As Waldie (1989) pointed out, operations with less than 800 transactions per year may find a bookkeeper more economical than a computerized accounting system.

The computer, and accompanying software, has not generally been embraced by the agricultural sector. Successful Farming Magazine, for example, predicted in 1983 that by 1990 80% of American farmers would be using micro computers to assist them in farm management by 1990 (Schmidt et. Al.). Yet a survey of 748 farmers in Nebraska in 1989 found that only 25% owned a computer (Sarno 1991), compared to a survey of 532 Nebraska farmers in 1983 for which only 3% owned a computer (Rochuel and Goding, 1984).

Of Nebraska farmers surveyed in 1989, 50% of non-owners felt that computers would be useful for their operation. Furthermore, 69% of owners had gross farm income in excess of U.S. $100,000 while only 38% of non-owners did, implying that high revenue farmers perceived microcomputer use as being more valuable than low revenue farms (Schmidt et. Al.).

Fourteen percent of Nebraska farmers used the computer for record keeping in 1989. Of all farmers surveyed, 63% indicated that they could improve record keeping on their farm. This 63% was made up of 76% of computer users versus only 60% of non computer users. The most frequent use of computers was word processing (73%), accounting (70%), maintaining production records (46%), marketing (20%) and feed formulation (10%).

The computer, as an information technology, appeared to have impacted what forms of media farmers use for gathering market information. Computer users were less likely to use newspapers (25% owners to 45% non-owners), radio (51% to 71%), and television (25% to 54%). In addition 54% of owners were more likely to use electronic marketing news terminals, compared to only 19% of non-owners, and perhaps reflecting the information value of computer technology users were more likely to use complex marketing strategies including hedging (12% vs 3%) with futures, and use of grain/livestock options (13%/14% to 2%/3%) (Schmidt et. al.) . This latter finding is consistent with Streeter's (1992) case studies in which successful users of information technology could 1) articulate their information needs; 2) had an adequate background in terms of education, commodity trading, and computers; 3) used electronic information to either save time or use time more efficiently; and had at least an overall management information system in their business which allowed information technology to improve overall decision making.

The adoption of computers in agriculture more closely parallel the in-house use of computers, rather than the business use. A 1994 Times Mirror study found that 33% of U.S. households owned computers, of which 10% had modems, and 6% used their computer to go on-line with the Internet. It is likely that this latter number has increased to match on-line usage with farm businesses. In Canada, it has been shown that while 40-50% of farm households own computers only about 20-25% use the computer for farm management purposes, implying that much of the computer use is for recreational purchases. Statistics Canada reports that in 1986

only 3% of Canadian farms owned computers, and this had risen to 11% by 1991, and as referenced above approximately 50% by 1995. According to the 1991 census 43% of farms with $500,000 or more in gross farm receipts used computers, while only 10% of farms grossing between $50,000 and $100,000, and only 6% of farms with less than $10,000 gross income used them. Statistics Canada correlated computer use with age (less than 55 years of age more likely) and education level. Whether or not farming was the primary operation did not appear to influence the computer purchase decision.

A final point about the studies of use of computers on the farm is that after a number of published studies in the late 1980's, the question of computer use per se appears to have decreased in importance. Most farm management researchers agree that "high-tech" is not necessarily "appropriate tech". Smaller, less complex operations may not benefit from a computer. Moreover, having farm records on a computer does not necessarily mean that more or better information is being obtained. Howard, Brinkman and Lambert report that "average" managers used computers primarily to keep accounts for tax purposes, while "top" managers used computers for planning and enterprise analysis. Yarbrough (1995) reports that while several studies report farmers use computers for enterprise analysis, very few farmers started doing enterprise analysis after purchasing a computer; i.e., a computer made the enterprise analysis quicker, but the farmer was doing enterprise analysis prior to having a computer.

Table 1. Percent of Farms Reporting Computer Use, by Year and Author.

Year	% Using Computers	Type of Farm	Author(s)
1982	2%	Iowa Commercial	Abbot & Yarbrough
1983	1%	NY Dairy	Lazarus & Smith
1984	4%	NY Dairy	Lazarus, Streeter & Jofre-Giraudo
1984	7%	NY Commercial	Abbot & Yarbrough
1984	6%	Iowa Commercial	Abbot & Yarbrough
1985	6%	NY Commercial	Abbot & Yarbrough
1986	15%	NY Dairy	Lazarus & Smith
1986	25%	Cal. Dairy	Putler & Zilberman
1987	24%	Ohio Commercial	Batte, Jones & Schnitkey
1987	15%	Iowa Commercial	Abbot & Yarbrough
1987	12%	NY Dairy	Lazarus, Streeter & Jofre-Giraudo
1990	21%	"Successful"	Iddings & Apps
1990	37%	Texas Rice	Jarvis
1992	18%	Ontario Beef	Howard & Filson

3.13.2 Computerized Livestock Production Records

Tremendous gains in livestock productivity have been due, in large part, to computer assisted analysis of vast amounts of genetic data. Dairy Herd Improvement programs, sire testing programs, and selective poultry breeding strategies are three examples that have had a major impact on livestock productivity. However, the great majority of the data analysis was done by off-farm researchers using main-frame computers. The use of mini-computers for on-farm recording and analysis of livestock production measures is similar to the use of computers for financial records: there are farms using computerized production records systems, but they are mostly the larger, "high-tech" farms. Few "average" sized livestock operation appear to have computers.

Computerized livestock record systems are mostly I) expert systems, or ii) health, breeding and production records. Studies that look at expert systems as management aids in livestock production generally concluded that such systems could benefit producers, but these evaluations have only been reported for experiment station or university herds (e.g., Spahr, Jones and Dill 1988, Favier and Dodd 1991, Spahr 1993). For several years the International Conference on Computers in Agricultural Extension Programs (1988, 1990, 1992, 1994) has had several papers on expert systems in livestock production, but not a single paper has reported an expert system in use on a commercial farm.

Production system software helps producers to monitor herd health practices (e.g., vaccinations), breeding and expected birthing dates, production measures, and ration analysis (Stowe 1988, Udomparasert and Williamson 1990). While it is relatively common to find both producers and veterinarians using computerized systems, Howard and Filson (1994) report that only about a third of the Ontario red meat producers they surveyed kept their production records on computers. Moreover, there appeared to be more interest in evaluating such systems in the late 1980's than there is currently. It is not heroic to assume that operations that are large enough and complex enough to benefit from a computerized system have one, and operations with fewer records do not.

3.14 Impact of New Information Technologies

Some researchers, rather than examining the "value" of information in agriculture have been concerned with the "impact" of technology. It is, however, unclear as to how "impact" and "value" are distinguished since a positive impact from a source of information would add value to a project, investment, or enterprise, while a negative impact would decrease value.

The issue of impact from information technology generally focuses on the extent by which farmers adopt information technologies; whether the information is of general interest to a broad spectrum of farmers; and do they provide the best source of information. Furthermore, there is a interest on the socio-economic influence on the use of information technology, i.e. is there a knowledge gap between the information "have" and "have not", and how does (electronic) information technologies affect the use of other information sources (Abbott 1989).

In directing these inquiries many researchers have viewed "impact" in the context of sociology than economics or value. For example Abbott and Yarbrough (1992) found that communication technologies have created substantial inequalities between farmers and that there is a strong and increasing adoption and use bias towards large scale farmers who have already developed skills for managing information. Likewise, Case and Rogers (1987) predict that information

technology will transfer agriculture into an information occupation which would widen the socioeconomic and information gap. Ironically these, and other studies, have indicated information technologies such as videotext for marketing livestock and crops is of dubious value (Case and Rogers), and although large scale farms are more likely to use information technologies, there is not a general perception that the technology has been of benefit (Abbott and Yarbrough). In fact, in a study by Clearfield and Warner (1984), it was reported that variables representing farm behaviour were unable to explain farmers use of information technologies, but were able to correlate the same characteristics with the adoption and use of other non-information technologies, which, interestingly, may suggest that the adoption pattern of information technologies differs from that of other farming innovations.

4.0 METHODS TO DETERMINE THE USE AND ECONOMIC IMPACT OF THE NEW INFORMATION TECHNOLOGIES

The review of previous studies on the economics of information provides a theoretical base for the empirical investigation of the economic impact of the new information technologies (computers, teletext/videotext systems, Internet communication systems, videotape systems, cellular phones, and geographical positioning systems). The literature indicates that information systems can not be evaluated separately from the information the system provides, and that information has unique characteristics. In particular, i) information has value when it affects actions and/or prior beliefs, ii) it can be an input and an output, but is unique as an input, as it does not have the same characteristics as a tangible input, iii) it can be a public good (i.e., non-rival and non-excludable in consumption, and iv) the value of information, and information systems, is highly subjective, depending on individual's utility function.

Mukhopadhyay (1988) describes six approaches that have been used to evaluate information technology in organizations (Section 3.12.2). Five of the approaches are prescriptive, where the criteria used to measure the value of the information technology is set by the evaluator, and only one approach is descriptive. Mukhopadhyay calls this descriptive approach the "user-oriented approach". This approach is similar to what Ahituv called the perceived value of information: the utility an individual receives from a set of information is best measured by observing the individual's actions and/or by eliciting their beliefs through their willingness to pay for that information. Four hypotheses are implicitly maintained when this approach is used. Each maintained hypothesis is discussed below.

First is that the economic impact of a new technology can not be evaluated separately from the information the new technology provides to a decision maker. The new technology may lower the cost of gathering, screening, editing the information, or increase the speed of access to information, but the value of the new information technology can not be separated from the information the technology provides.

Second is that the value of information is highly subjective, based upon an individual's utility function, and hence varies across situations, levels of risk preferences, levels of wealth, and other individual characteristics. Following Hilton (1981) (Section 3.7), a decision maker values information (and the system providing that information) according to how much s/he would be willing to pay to gain access to an information system and be no better and no worse off than s/he expect to be without that access; i.e., utility with the information minus the cost of the information is equal to utility without the information.

Third is that utility functions are unobservable so that it is not possible to empirically measure utility. However, actions and the use/non-use of a particular technology is observable, and it is the use of a technology and the manner in which it is used that indicates the value of the technology.

Fourth, the subjective value an individual has for information can be elicited through asking the willingness-to-pay (WTP) for a particular type of information. This method is common in market research studies, but has only recently been accepted by economists and is most common in valuing non-market goods (e.g., Mitchell and Carson 1989). By varying the asking price for a good or service, the percentage of people willing to pay a particular price can be obtained. Demand for that good or service can then be estimated according to the percentage of the sample willing to pay for the good or service at a particular price, with the area under the demand curve the cumulative probability of demand at various prices.

The accuracy of WTP methods has been questioned. At issue is the respondent's bias or difference between their stated WTP and the actual or demonstrated WTP. Two major sources of bias have been termed "strategic bias" and "hypothetical bias". Strategic may happen when a rational economic agent has incentives to not reveal their true demand for a public good or service; in effect, second guessing the intentions of the survey (Samuelson 1954). Hypothetical bias stems from respondents not being familiar with the good or service in question. In a real market, there are many opportunities to become familiar with a particular good or service, and to have several price observations. It is impossible for a brief survey to duplicate the experience and information gained in a real market. If a real market is necessary for a consumer to become familiar with a new good or service, then hypothetical bias will always exist to some degree.

Whether strategic and hypothetical biases actually exist and their size are empirical questions. First, a large number of studies have that strategic behaviour in a WTP context is difficult to document and appears to have a small affect on survey results (Bishop and Heberlein 1990). Second, WTP results have been found roughly comparable travel cost methods (Sellar, Stoll and Chavas 1985), hedonic price models (Brookshire et al. 1982) and costs and prices of substitutes (Thayer 1981). Biases may exist with the WTP method, but it is the best available method for eliciting subjective evaluations of a good or service.

A further issue associated with the WTP approach is that the functional form of an demand function be consistent with the underlying utility theory (Hanemann 1984). There is debate on the relative importance of theoretical consistency and statistical goodness of fit. Hanemann (1984) questions the validity of demand functions that are not theoretically consistent, while Bishop and Heberlein (1990) argue that as long as a demand curve is negatively sloped, statistical significance is more important than theoretical consistency.

Considering the issues outlined above, the user-oriented approach was the method chosen for evaluating the economics of the new information technologies. Use/non-use, WTP, and personal and business characteristics were evaluated at two levels in the agrifood system: i) on the farm and ii) in agribusinesses. Details of the methods used at the two levels of the agrifood system are discussed below.

4.1 Survey of Canadian Farmers

Canadian commercial farmers were survey by telephone to determine the percent who used the new information technologies, their attitudes about the technologies, and personal and farm

characteristics. The sample was stratified by farmers who had reported farm incomes of $50,000/year or more. The sample included farmers from all provinces. The survey was conducted by telephone during February, 1996. The survey instrument is in Appendix II.

Previous studies of adoption of new technologies found age, education level, size of operation and type of operation significantly correlated with use/non-use of a new technology. Information on farmer and farm characteristics was obtained to do similar analysis. Additionally, direct questions about how the technology is used, attitudes about the technology and WTP measures were asked.

4.2 Agribusiness Interviews

Agribusinesses were surveyed to determine the impact of new information technologies pertinent to their businesses. Given the wide variety of types, locations, organizational structure (e.g., investor-owned-firm, co-operative), and focuses, these interviews were more individual case studies than structured surveys. Hence, each agribusiness interview followed similar guidelines, but varied according to the firm and individual interviewed. The interview guidelines are reported in Appendix III.

For each interview, an attempt was made to interview a CEO or marketing or operations manager who uses information and communication systems to make periodic (e.g., day-to-day or weekly) decisions. In all cases questions about current and anticipated use of new information technologies (i.e., computers, teletext/videotext, Internet, videos, cellular phones, and GPS) were asked. In general, three basic questions were asked of all agribusiness firms and organizations: i) how have changes in information technology affected your organization; ii) what changes do you anticipate in the near future; and iii) what value do you place (or willingness to pay) for information critical to your continued operation? A partial list of the type of agribusiness firms and organizations interviewed is reported in Appendix IV. It is a partial list because several companies and individuals were willing to be interviewed, but requested that their names not be released.

Government agencies were also interviewed to review the types of information for which they are primary sources, which types secondary sources, and expected changes associated with the new information technologies. A partial list of government agencies interviewed is reported in Appendix IV.

5.0 RESULTS OF FARM SURVEY AND AGRIBUSINESS INTERVIEWS

5.1 Farmer Use of New Information Technologies

The purpose of this section is to detail the results of the telephone survey, provide an economic interpretation of the results, and provide elasticity estimates for the demand for information.

5.2 Farmer Survey Results

A telephone survey was conducted during the first 2 weeks of February 1996. The sample was randomly selected from the mailing list for Country Guide Magazine. These farms had been categorized as having farm incomes of $50,000/year or more, even though some of the farm

reported incomes of less than $50,000 in 1995; in previous years they had reported farms incomes of $50,000/year or more.

Of the 502 respondents, 69.5% were from the western provinces, 20.6% from Ontario and Quebec, and 10% from Atlantic Canada. Of these 34.4% were beef producers, 13% dairy, 4.9% hogs, 45.3% cash crops, and 2.4% horticulture, poultry, and other. 45.3% of respondents were 45 years of age and under, and 54.7% were over the age of 45, and 36.7% of respondents were female while 63.3% were male. 66.7% of respondents had at least graduated from high school with 27.4% completing either a college diploma, or university degree, and 4.6% having post graduate or professional training.

From an economic perspective, 21.7% of respondents reported gross sales of $50,000 or less in 1995, 45.6% had gross sales less than $100,000, 67.3 % were less than $150,000, and 79% had gross sales less than $200,000. Only 21% of respondents had sales in excess of $200,000. Net farm income was also recorded. Of respondents, 61.1% had net income of $50,000 or less, 15.3% had net income between $50,000 and $74,000; 10.4% had net income of between $75,000 and $100,000; and 13.1% reported net income in excess of $100,000.

5.3 Farmers' Use of Computers and Information Technology

Survey results indicate that the number of on farm computers has been increasing, and it appears that the rate of adoption is increasing modestly. For example 49.3% of farms now have computers, while 50.7% do not. Of those farmers owning computers 18% had purchased the computer since January, 1995, 19.2% purchased in 1994, and 15.1% purchased in 1993. Approximately 48% of farmers owning computers had purchased computers over 3 years ago. The use of computer technology also appears to be sustained since 32.1% of respondents owning computers indicated that they were now using a second computer purchase, and 7.7% indicated that they had purchased at least 3 computers over time.

The 50.7% of farmers that do not yet own computers were asked why they had yet to purchase one. Cost and need were identified as the 2 most significant barriers to adoption. For example 32.8% of non computer users indicated that they did not see a need for computers on their farms, while 32.2% stated that cost was a limiting factor. Complexity (9.2%), lack of training (8.8%), and availability of software (2.4%) were identified as key factors limiting adoption. Other reasons, such as age or retirement made up the responses for 15.2% of the sample..

5.4 Comparison of Computer Users and Non-Users

The theoretical survey, and literature review indicated that several factors may influence computer technology adoption. Because of the recency of the technology it is expected that older farmers would be less likely to adopt technologies than younger farmers; more profitable farmers would be more likely to adopt technologies, and more educated farmers would be more likely to understand the technology.

Table 2 summarizes the results of this query. The first column identifies the farm characteristic, the second and third columns reflect the % frequencies relative to the population falling into each category (use computer, don't use computer). A LOGIT model was estimated using the qualitative description variables described in this section. The overall prediction accuracy was approximately 68%. The results of the LOGIT model do not provide more insights than the

simple frequencies reported in Table 2; the LOGIT probabilities were approximately the same as the frequencies, and hence are not reported.

As expected, age is a factor in computer adoption. Younger producers are more likely to adopt computer technology than older producers. For example up to age 56, their is a greater propensity to adopt the technology, than after age 56. There is a 75% chance that a farmer aged 25 years or less will own a computer, but only a 22.5% chance that a farmer over the age of 56 would own a computer. Of the 120 respondents claiming to be over 56 years of age, only 27 (22.5%) used computers, while 93 (77.5%) did not.

Gender does not appear to be a distinguishing factor in computer adoption and use. As indicated in Table 2, even though there was a greater number of male respondents, the frequency of computer use was virtually the same between the groups. In general there is a 50% chance that a female manager would use a computer, which is virtually indistinguishable from the 49% probability associated with male use of the computer.

Education is an important determinant of computer use. Of the 11.1% , or 55 respondents, who completed at most primary school, the majority, 70.9%, did not use computers. In fact only 16 (29%) of the 55 primary school graduates reported using a computer. In contrast only 44, or 8.9% of respondents had completed at most a university degree. Of this group 31 (70.5%) used a computer. In general, the probability that a farmer uses a computer increases with their level of education.

Gross revenue (and net income which is not shown) also provides an indication of computer use. In general, farmers with greater revenues are more likely to use a computer than low revenue farmers. For example, 21.7% of respondents indicated gross sales of less than $50,000. Of this group of 93 producers only 38 (40.9%) used computers, while 55 (59.1%) did not. In contrast there were 90 farmers indicating gross sales in excess of $200,000 representing about 21% of all respondents. Of this group a clear majority, 60 out of 90 , or 66.7%, used a computer, while 30 (33.3%) did not. This is virtually reversed from the group earning less than $50,000. In general the LOGIT probability that a farmer with less than $50,000 in gross sales using a computer is only 38.4%, while the probability of a farmer with sales ranging from $101,000-$150,000 using a computer is about 50.2%, and farmers with sales in excess of $200,000 have a likelihood of 64.2%.

Farm type does not appear to have as significant an influence on computer use as age, education or gross sales. Horticultural groups (mostly potatoes) had the highest frequency of computer use, however there were only 3 observations in this class. Dairy and hogs, representing 17.9% of respondents had frequencies of up to 58%, while beef farms representing 34.3% of respondents had only a 44% using a computer.

Table 2: Sample statistics for computer owners and non owners			
Category	Total Percent Responding	No Computer (Percent of Category)	Use Computer (Percent of Category)
	Gender Differences		
Male	36.6%	50%	50%
Female	63.3%	51%	49%
	Age Characteristics		
18-25 years old	3.2%	25%	75%
26-35 years old	12.1%	46.7%	53.3%
36-45 years old	29.8%	36.1%	63.9%
46-55 years old	30.6%	47.7%	52.3%
> 56 years old	24.3%	77.5%	22.5%
	School/Academic Characteristics		
Primary school or less	11.1%	70.9%	29.1%
Some high school	11.5%	57.9%	42.1%
Completed high school	32.1%	58.5%	41.5%
Some college/university	13.1%	50.8%	49.2%
College diploma	18.6%	31.5%	68.5%
University degree	8.9%	29.5%	70.5%
Post graduate/professional	4.6%	47.8%	52.2%
	Gross Sales		
Gross sales < $50,000	21.7%	59.1%	40.9%
Gross sales $51,000-$100,000	23.8%	62.7%	37.3%
Gross sales $101,000-$150,000	21.7%	47.3%	52.7%
Gross sales $151,000-$200,000	11.7%	40.0%	60.0%
Gross sales > $200,000	21.0%	33.3%	66.7%
	Farm Type		

Table 2: Sample statistics for computer owners and non owners			
Category	Total Percent Responding	No Computer (Percent of Category)	Use Computer (Percent of Category)
Beef farm	34.3%	55.6%	44.4%
Cash crops	45.4%	50.9%	49.1%
Dairy	13.0%	42.2%	57.8%
Hogs	4.9%	45.8%	54.2%
Hort, poultry,other	.24%	25%	75%

5.5 Why Farmers Don't Use Computers

An important consideration in determining the value of information technologies is determining the reasoning behind the decision not to adopt computer technologies. Farmers indicating that they do not use computers were asked why they have not considered the technology. Their responses are summarized in Table 3.

Table 3: Reasons for not using computer technologies (250 non users)		
Reason	frequency	percent
Too complex	23	9.2%
Too costly	79	31.6%
No need	82	32.8%
Lack of Software	6	2.4%
Inadequate training	22	8.8%
Other (e.g. too old, retiring)	38	15.2%

The two most limiting factors to computer technology seem to be cost and need. Over 31% of farmers not using computers indicated that the cost was prohibitive. On average farmers using computers report systems costing about $2,800. However there are also unknown costs associated with training, software, and software upgrades which can increase the cost significantly.

A more intriguing figure is the 33% of respondents who see no need for computer use on the farm. This could be a function of the applications software available or the size of the farming operation. It is interesting that this group did not indicate any anxiety with respect to computer use with only 9.2% indicating that computers are too complex, and only 8.8% indicating that training was inadequate. It would appear that applications software is limiting to only a small number of farmers, however it is unlikely that farmers would be aware of the software market if they were not using a computer.

To gain an understanding of what would encourage farmers to use a computer a hypothetical, but not unrealistic, application of software which would allow them to communicate with lenders and suppliers was described to respondents. Only 24.5% of respondents indicated that they would be very likely, or would likely purchase a computer if such an application and service was made available. Clearly 73.8% indicated that even if such technology was available they would not readily adopt it.

This result may indicate that farmers who have not yet purchased computer and information technologies, are not laggards, in the sense of the traditional leader-laggard paradigm, but resistors to technological change. If so, the result may indicate that growth in the numbers of farmers adopting information technologies may be slowing down. In targeting this group of farmers it is important to focus on, and illustrate the benefits of information technology, and be able to demonstrate a cost-value relationship.

5.6 Why farmers use computers

This research is very much focused on the value of information and information technologies to farmers and agribusiness. To assess the value to farmers, respondents who indicated ownership of a computer were queried on it importance to the household and the farm operation. The nature of the questions recognizes that ownership of a computer does not necessarily indicate that it contributes value to the farming operation.

The first question asked of respondents was to indicate why they purchased a computer in the first place. The intent of this question was to derive whether or not farmers had some a priori expectations about its use on the farm. The second question queried respondents on what aspects of farm and family life the computer was used for, and to what extent the computer was used for various farm and family functions. The third query was intended to derive an ex post assessment of the value of computer technology and whether or not farmers perceived the computer as providing value relative to its cost.

Table 4 lists the responses to queries on why farmers first purchased the computer.

Table 4: When you first considered purchasing a computer to what extent were each of the following a consideration?			
Criteria	Not a consideration	Somewhat important	Very important
Use for farming	15.1%	42.0%	42.0%
Use for non-farm work	24.1%	50.2%	25.7%
Use for household records or decisions	56.3%	38.0%	4.9%
Use in education of family members	22.0%	34.7%	43.3%
Use for learning how to use computers	30.6%	44.1%	23.7%

A significant proportion of respondents (84%) indicated that the computer was purchased to assist in the farming operation, although with 76% responding favourably towards non-farm uses the diverse applicability of the computer appears to be apparent to these farmers. The computer was not generally purchased for household decisions with less than 45% of respondents indicating importance of this criteria. However, although the computer was not purchased to fulfil a household function, its educational value was recognized with approximately 78% of respondents indicating that education was important. The results also indicate a willingness by farmers to gain hands-on instruction from the computer with 66% indicating that learning to use the computer was an important consideration. However this was perceived as being less important than the farm management and educational aspects of computer purchase.

Once purchased, respondents were asked what function the computer played in their business decisions and family. The questions and responses are summarized in Table 5.

Table 5: To what extent is your computer used for the following applications				
	Almost none	A little	Quite a bit	A lot
Keep general farm accounting records	13.9%	14.9%	19.6%	51.5%
Keep enterprise accounts	36.6%	25.8%	14.9%	22.7%
Tax preparation	34.9%	20.8%	13.5%	30.7%
Keep inventory and/or depreciation records	30.1%	26.9%	17.6%	25.4%

Table 5: To what extent is your computer used for the following applications				
	Almost none	A little	Quite a bit	A lot
Establish budget for operation and monitor budgeted vs actual revenues and expenses	38.2%	28.3%	15.7%	17.8%
Manage payroll	68.6%	16.0%	7.7%	7.7%
Run decision aid programs for management	60.3%	21.2%	12.7%	5.8%
Run crop or livestock management programs	40.0%	25.8%	18.4%	15.8%
Do word processing for farm business	21.6%	47.9%	17.0%	13.4%

The results illustrate the use of computers in farm management. By far the most active use of the computer is in the recording and maintenance of farm records for accounting purposes with about 71% of respondents indicating significant computer use. Other aspects of accounting such as tax preparation and the maintenance of inventory and depreciation were not ranked as high, perhaps because specific software for these applications have not readily been developed, whereas accounting software is available from a number of sources in Canada. Furthermore, payroll accounting does not play a significant role in most atomistic family farms, so the infrequent use of computers for this purpose may be a greater reflection on the nature of the farming operation, rather than the willingness of farmers to adopt the technology per se. Traditional farm management such as budgeting, and financial planning does not play a significant role in the use of the computer. Only 37% indicated use for enterprise analysis, and only 33% indicated use of the computer for budgeting and making financial projections. Again this may be due to the lack of available software specific to each commodity group. The results also do not indicate whether application software was purchased or developed on the farm.

The extent by which the computer was utilized for farm and family purposes was also evaluated. Results are presented in Table 6.

Table 6: Approximately how many hours a week does your family spend on the computer.					
hours/week	none	< 2 hours	2-5 hours	5-10 hours	> 10 hours
Farm / business work	20.5%	29.1%	28.3%	13.5%	8.6%
off-farm business	25.4%	28.7%	23.4%	11.9%	10.7%
educational uses	23.7%	25.3%	31.1%	13.3%	6.6%
recreation/entertainment	25.3%	33.2%	22.0%	13.7%	5.8%
personal use	29.0%	52.1%	12.6%	3.8%	2.5%

The use of the computer as a family/business technology is readily apparent from Table 6. While respondents indicate significant use for business purposes, use is relatively evenly dispersed across other aspects of family life. For example while 22% of respondents indicate spending more than 5 hours per week on the computer for farm business purposes, they are spending an equivalent amount of time on educational use (20%) and recreation (19.5%). While education and entertainment appear to be significant uses of the computer, this may be due to school age children. It does not appear that adults spend considerable amounts of time using the computer for their own personal affairs. The results also show significant use of the computer for non-farm business purposes. Perhaps, respondents were unable to distinguish between off-farm business and personal affairs.

Table 7 displays questions asked of computer users in regards to their perception of the benefits derived from computer use.

Table 7: How has your computer affected your farming operation					
Criteria	Strongly agree	Agree	Disagree	Strongly Disagree	No experience
Keep more detailed farm records	25.5%	43.2%	17.2%	4.2%	9.9%
Computer hasn't changed the way I manage	3.2%	49.5%	33.2%	7.4%	6.8%
Producing immediate financial reports has value	30.2%	52.1%	6.3%	1.0%	10.4%
Calculating answers to 'What if?' questions has made money for me	5.3%	34.4%	25.9%	5.8%	28.6%

Computer has helped me identify problems and opportunities	5.8%	36.6%	30.9%	5.2%	21.5%
Keeping records with a computer is more trouble than it is worth	3.2%	17.8%	46.5%	19.5%	13.0%
Computer allows me to know my financial affairs and analyze business performance more precisely	25.0%	46.9%	13.5%	3.1%	11.5%
Using a computer has allowed me to expand my farming operation.	5.9%	28.7%	33.5%	5.3%	26.6%

The results indicate that the computer has provided significant value to the farm operation, while the range of 'No experience' is from 10% to 28%, the results do indicate that a significant number of farmers are using the computer as a decision aid. This is particularly evident in the use of the computer for accounting where over 68% of users indicate that record keeping has improved, and 82% find value in the immediacy of providing financial reports and summaries, and 72% find that the computer allows farmers to know their business better. However, the computer is not a panacea for change. 52% of farmers suggest that the computer has not really impacted the way they manage, although 42% do admit that the computer has helped to identify problems and opportunities, and a further 34% attribute expansion of the farm to the use of computers. Overall, there is a general satisfaction with the computer as a management technology with only 21% of respondents indicating that record keeping with the computer was more trouble than it was worth.

When asked to balance out the perceived value of the computer relative to its cost, 65.6% of respondents indicated a significant gain, with 12.4% being a substantial net gain. Only 30.6% indicated that they had neither gained or lost in terms of benefits derived from the computer, while 3.7% of respondents indicated that they had lost money because of the computer.

5.7 Farmers' Use of Other Technologies and Information

The new information technologies are not confined to computer use and software applications. Information technology is much more broadly defined in terms of communication technologies such as 2-way radios and cellular phones, as well as information services for commodity prices and weather updates and forecasts. This section presents results from queries to respondents in regards to their use of communication technologies and their willingness to pay for information.

5.7.1 Farmers Use of Information Technologies and Services

The purpose of this section is to provide an indication of farmers' adoption of information technologies outside of the realm of software applications. DTN, Reuters, and other systems require a special device, or receiver, to receive FM sideband or DBS microwave satellite signals via monitor. These technologies are generally stand alone technologies which may or may not require a personal computer.

Information technologies which use a computer require a modem and telephone hookup to a remote server. Computer bulletin boards such as FBMInet, SCAMP, Agridata, Instant Update, are all server applications which are accessed by dialling in to a remote site to garnish information. An alternative information technology which also requires a modem is the Internet and World Wide Web. These information sites are available by paying a service provider such as Compuserve, HookUp, America On-Line, and provides access to E-mail and electronic bulletin boards.

Table 8, indicates farmers' use of these technologies. Respondents are those farmers who currently own computers.:

Table 8: Farmers' Use of Information Technologies

Technology	Currently using	Have used in the past	Have never used it
DTN, Reuters etc	6.8%	4.2%	88.9%
FBMInet, SCAMP, Agridata, Instant Update, by Modem	6.7%	4.1%	89.1%
Compuserve, and Internet/WWW access, and E-mail	8.9%	5.2%	85.9%

As indicated in Table 8, the adoption rate of information technologies is not very high. Only 6.8% of farmers use satellite broadcasts, 6.7% use agricultural bulletin boards, and only 8.9% have access to the World Wide Web. Interestingly, the attrition rate is very high. For example 4.2% of respondents indicated that they had used agricultural bulletin boards in the past but are no longer using them. In all cases well over 85% of respondents stated that they had never used these technologies.

5.8 Willingness to Pay

Part of the reason that farmers are not adopting the information technologies could be that the value they place on the technology is less than the cost of obtaining that information. Farmers were asked specifically how much they would be willing to pay for three types of services ranging from bank transfers, and supplier prices, to futures prices for livestock and cash crop, and price forecasts. The responses, summarized in Table 9 include both farmers who own a computer and those farmers who do not own a computer but were willing to consider purchasing one if the correct information services were provided. The group of non-computer-owning farmers were asked if they " ... could use a computer to communicate with [their] banker or accountant to check balances, or with an input supplier to check prices or to order inputs and deliveries, and other business transactions. ..." would they be more likely to buy a computer. Of the non-users, 26% said that such a service would make them more likely to buy a computer.

Both groups (i.e., computer uses and non-users who would more likely buy a computer if the information services were available) were asked their willingness-to-pay for the ability to communicate with their banker, accountant, and other business associates, and/or market information in the form of i) current futures prices on the CBT, Mercantile Exchange, etc., ii) current grains, oilseed and/or livestock cash prices on local, regional and North American markets, and iii) forecasts of grain, oilseed and/or livestock prices three months in the future. Prices for these information series were varied from $0/month to $25/month. The percentage of respondents willing to pay at each price for the different information series are reported in Table 9.

Table 9: Willingness to Pay for Market Information

	Don't own computer (64 respondents)	Own computer (244 respondents)	Total (308 respondents)
	Communicate with banker, accountant, suppliers etc.		
$0/month	20.3%	37.3%	33.8%
$5/month	18.8%	22.5%	21.8%
$10/month	32.8%	16.8%	20.1%
$15/month	7.8%	5.3%	5.8%
$20/month	4.7%	2.5%	2.9%
$25/month	6.3%	5.7%	5.8%
Don't Know	9.4%	9.8%	9.7%

Table 9: Willingness to Pay for Market Information			
	Don't own computer (64 respondents)	Own computer (244 respondents)	Total (308 respondents)
	Obtain current futures and commodity prices from CBT, CME etc.		
$0/month	23.4%	40.6%	37.0%
$5/month	26.6%	24.2%	24.7%
$10/month	25.0%	14.3%	16.6%
$15/month	10.9%	4.9%	6.2%
$20/month	1.6%	3.3%	2.9%
$25/month	6.3%	4.5%	4.9%
Don't Know	6.3%	8.2%	7.8%
	Obtain crop and livestock cash prices		
$0/month	35.9%	44.3%	42.5%
$5/month	23.4%	22.1%	22.4%
$10/month	23.4%	18.0%	19.2%
$15/month	4.7%	2.9%	3.2%
$20/month	3.1%	3.7%	3.6%
$25/month	6.3%	2.0%	2.9%
Don't Know	3.1%	7.0%	6.2%
	Obtain forecasts of commodity prices 3 months ahead		
$0/month	35.9%	47.1%	44.8%
$5/month	17.2%	20.5%	19.8%
$10/month	25.0%	14.3%	16.6%
$15/month	6.3%	3.7%	4.2%
$20/month	3.1%	2.9%	2.9%
$25/month	3.1%	3.3%	3.2%
Don't Know	9.4%	8.2%	8.4%

As reported in Table 9, a large number of farmers do not put a great monetary value on information, whether it be for communicating with professionals such as lenders and suppliers, or obtaining market information on futures prices, cash prices, or price forecasts. In general, at least 1 out of 3 farmers would not be willing to pay anything for information services, and 2 out of 3 farmers would not be willing to pay more than $10/month for theses services. Transactions data related to banking and conducting business transactions appear to have greater value than commodity prices or price forecasts. Perhaps this is because prices are readily available from local depots, merchandisers, and elevators, or farmers are more likely to lock in forward prices rather than use futures contracts.

Non-computer owning farmers generally had a higher WTP for the services than did farmers who owned computers. This is demonstrated in Table 9, and illustrated in Figures 11 through 13. As discussed in Section 4.0, a stated WTP can be higher than an actual or demonstrated WTP. The higher WTP of non-computer-users may be due to a higher WTP for a hypothetical good or service compared to a demonstrated WTP. As a whole the dimminishing willingness to pay as price increases for all four services discussed in Table 9, can be seen in Figure 14. In general, respondents to the survey indicated a greater willingness to pay for bussiness and communicating services, than futures and cash prices, and were willing to pay the least for economic price forecasts. This result may be a consequence of the nature of information provided. For example the notion of Internet communication and E-mail is foreign to over 90% of respondents so, to them, the conceptual idea of on-line communications with business associates may not be clear in terms of content or value. This may change with the increasing number of Internet providers and communication companies setting up in rural areas, and with increased use of the Internet by local, national, and international product and service providers. In addition, not all farmers may value the futures market as use of futures markets is generally very low, and cash prices for commodities are as easily communicated by news print or telephone communication. Thus the low willingness to pay for services may not reflect a rejection of the technology, per se, but rather a general sentimment that there is not a great urgency for on-line and real-time

communications of economic information. Finally, communicating 3 month price forecasts has the lowest willingness to pay among respondents, which may reflect an underlying perception that such information is ambiguous relative to observed cash and futures prices, or that forecasts are more relavent to hedgers and merchandisers than farmers. This latter hypothesis would be consistent with a lower willingness to pay than for futures and cash prices.

With the caveat that a stated WTP may be a biased approximation to the true WTP (see Section 4.0), the farmer's WTP is consistent with a downward sloping demand curve, as can be seen in Figures 10 through 14. As price/month for the information series increases, fewer and fewer farmers are WTP for the information. To assess this demand in terms of elasticities, a simple exponential regression was estimated using the form

$$\text{Demand frequency} = a + \text{EXP}(b * \text{Price}) + e$$

where the demand frequency was the percentage of farmers WTP a given price for the information, EXP is the natural exponent, e is an error term, and a and b are parameters. An advantage of this functional form is that the parameter b is the estimated elasticity for the equation. In this case, b is the estimated elasticity of demand for the information series, or how responsive the number of farmers willing and able to buy the information are to the price of the information.

Figure 10: Stated Willingness to Pay for Electronic Communication with Professional Services and Businesses

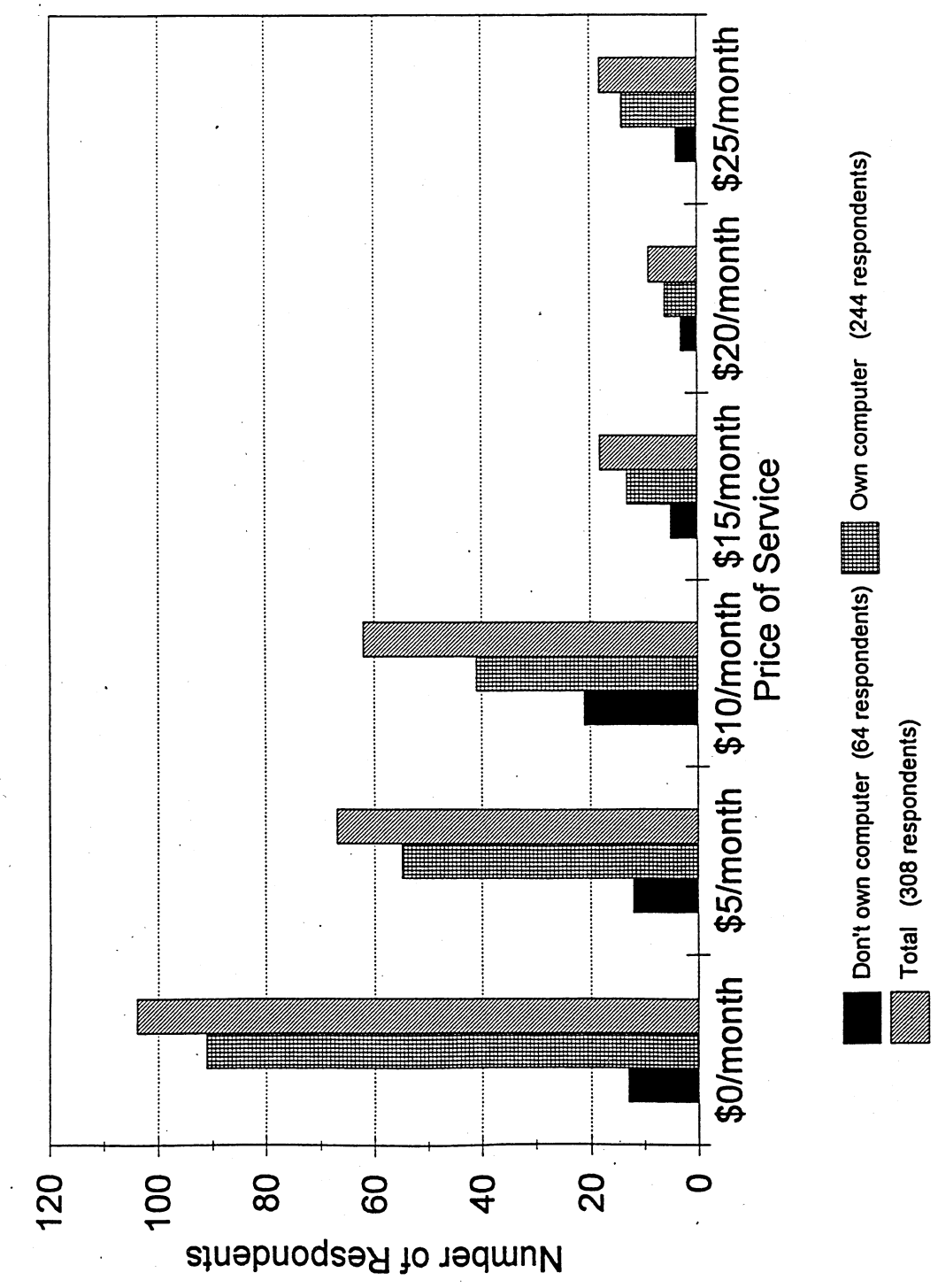


Figure 11: Stated Willingness to Pay for Electronic Communication of Cash Crop and Livestock Futures Prices

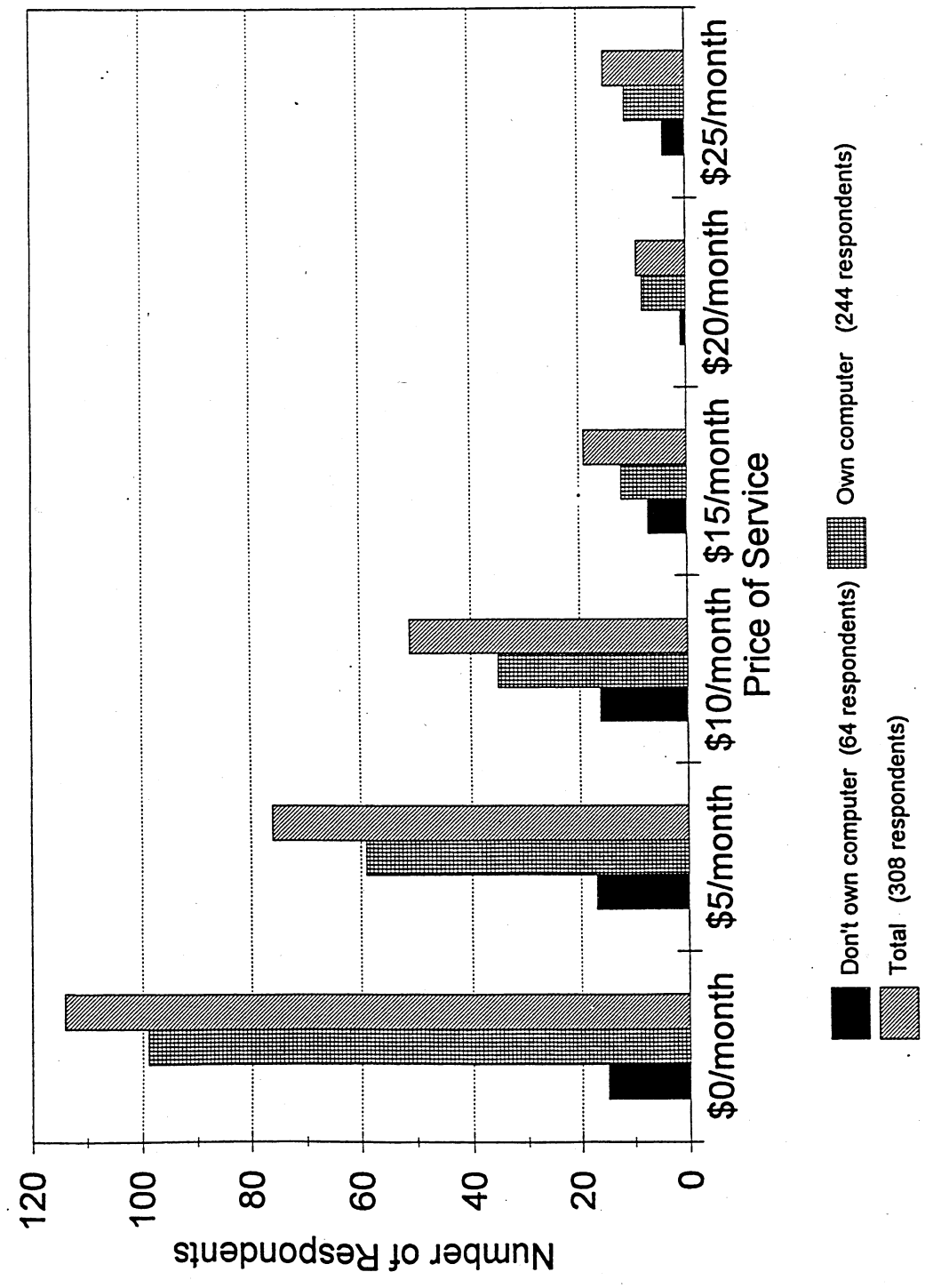


Figure 12: Stated Willingness to Pay for Electronic Communication of Cash Crop and Livestock Cash Prices

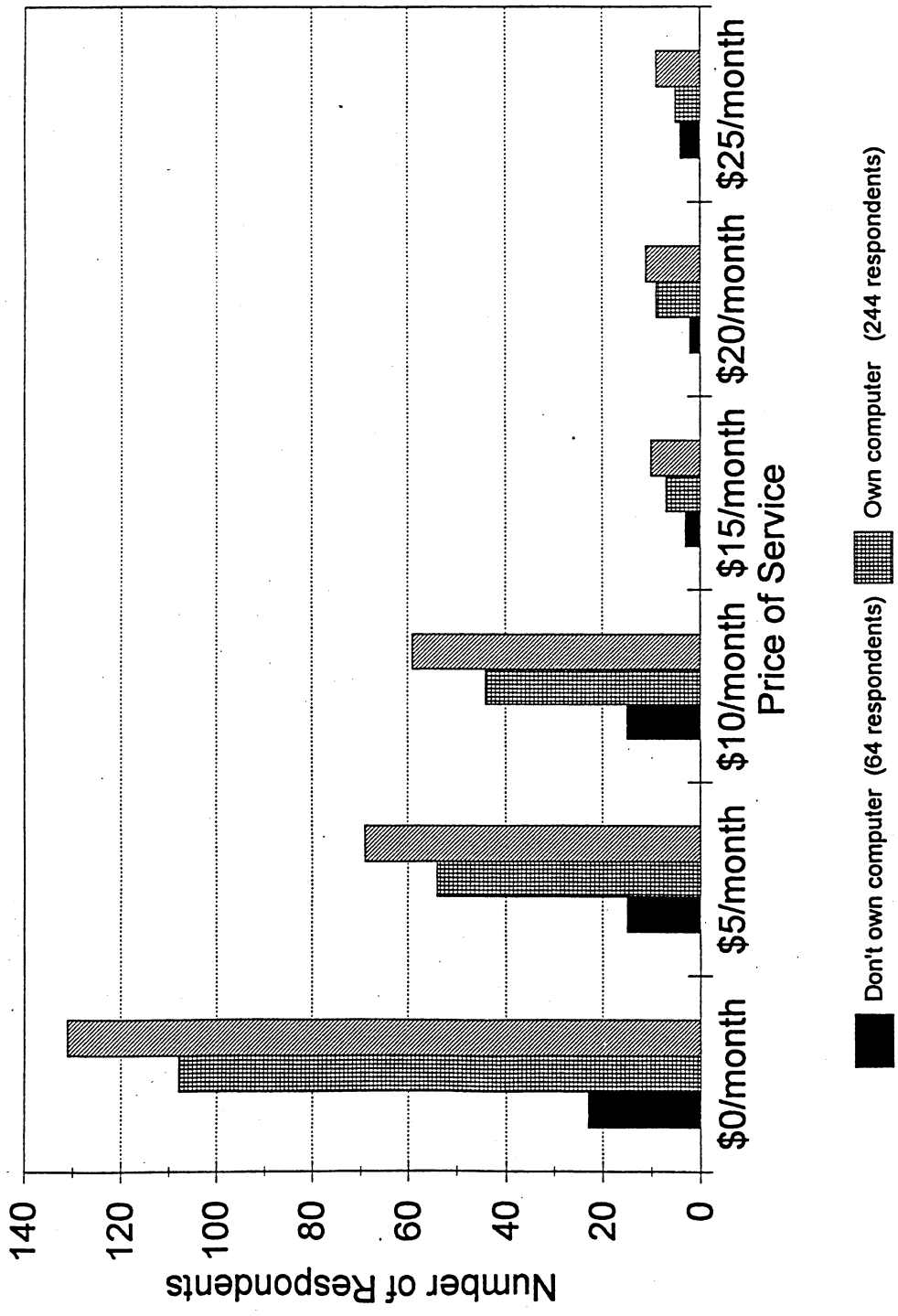


Figure 13: Stated Willingness to Pay for Electronic Communication of Cash Crop and Livestock Price Forecasts

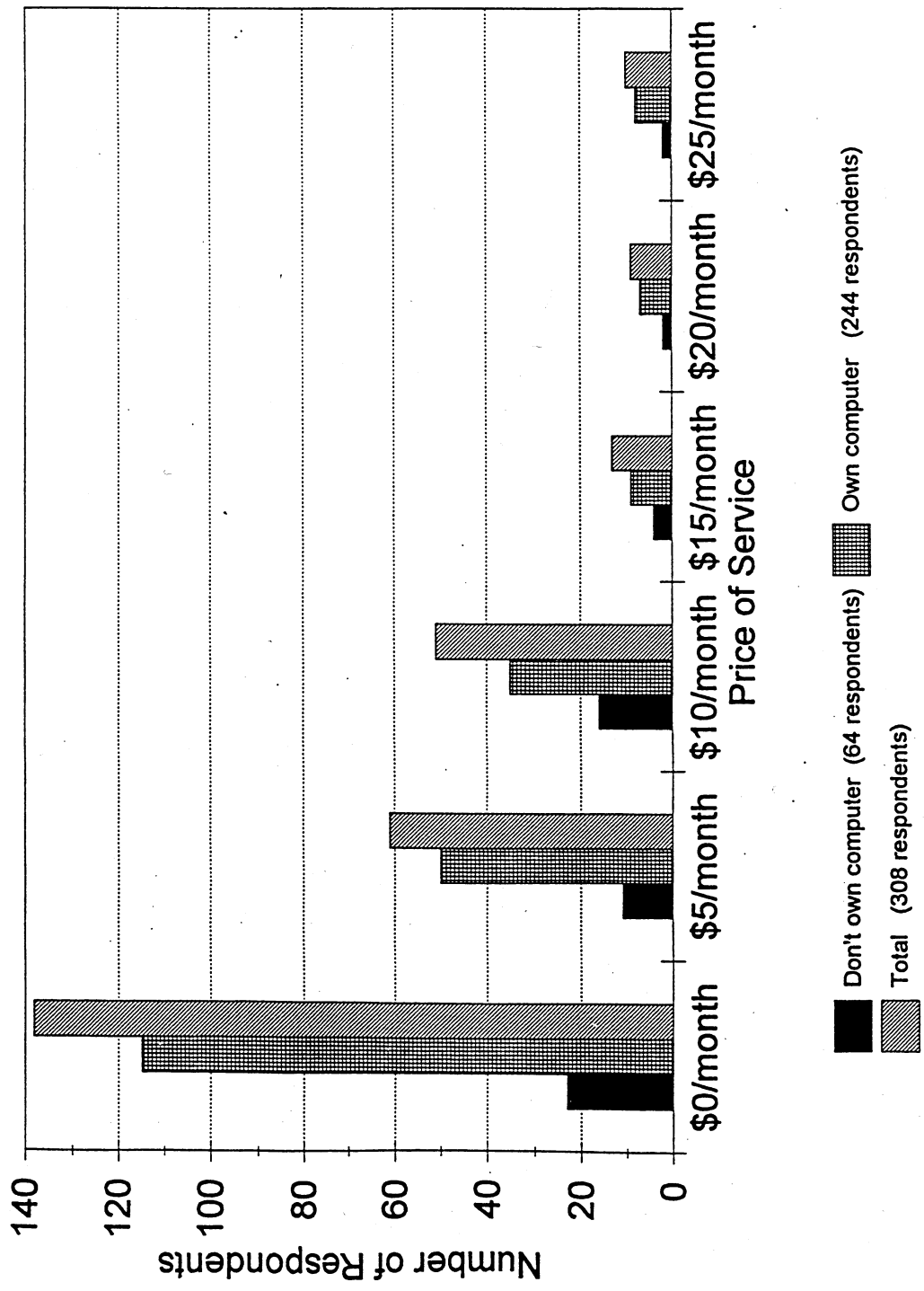
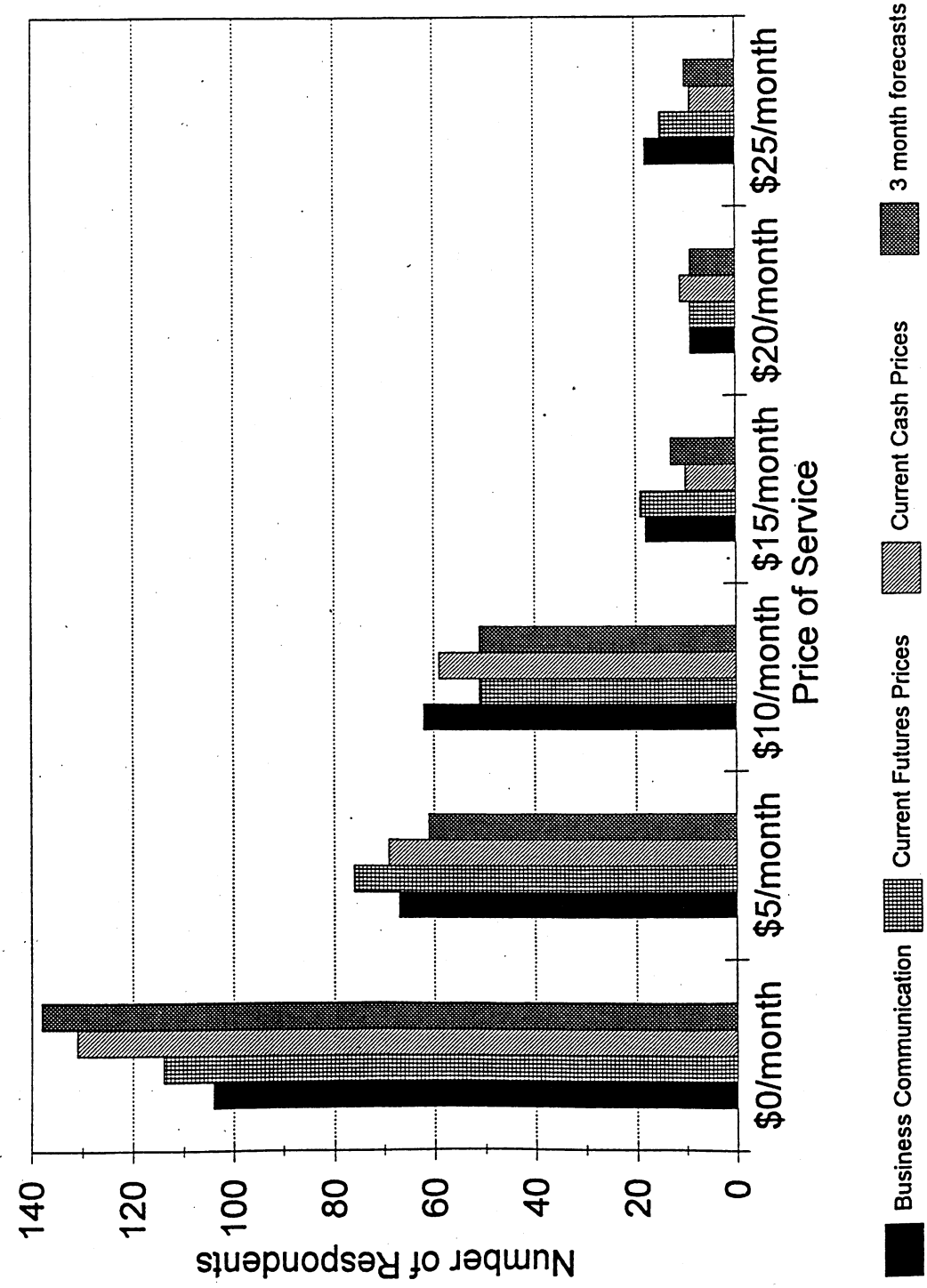


Figure 14: Stated Willingness to Pay for Electronic Communication Services, All Respondents



The results of the regression reported in Table 10 suggest that the demand for economic information is very inelastic; i.e., |b| < 1.0. It is reasonable to assume that the farmers who are familiar with similar services are aware of the value of such information, hence the very inelastic demand. For them, information is a necessary input which has no real substitute.

Table 10: Elasticity estimates for Demand for Information

Demand Item	Intercept (a)	Regressor coefficient and Elasticity (b)	F -Stat. (%)	R sqr
Communicate with banker, accountant, suppliers etc.	40.54	-.1056	28.78 (.006)	.878
Obtain current futures and commodity prices from CBT, CME etc	43.39	-.122	28.88 (.006)	.878
Obtain forecasts of commodity prices 3 months ahead	42.62	-.121	38.86 (.003)	.907

The percentage of farmers WTP for the hypothetical information series is consistent with the 7%-9% of the farmers surveyed who use information services such as DTN or are on the Internet.

5.9 Farmers' Use of Communications Technology

In addition to computer use and information providers, information technology also envelopes communications devices such as Video Cassette Recorders (VCR), cellular phones and 2 way radios. The importance of these technologies rests in how, and to what extent they are used in the deliverance, and processing of information, and as such what value they have to farmers.

The VCR is mostly regarded as an entertainment system rather than an information system. However in addition to its use for entertainment it can also be use to display educational videos, and thus has value as an information technology. Approximately 88.5% of all respondents own a VCR. Of these 51.3% also own a computer while 48.7% do not. Of the 21.5% of respondents who do not own a VCR, 66.7% also did not own a computer, which may indicate a preponderance of non-computer users to avoid new technologies in general.

The VCR as an information technology was measured by asking respondents to what extent they used the VCR for entertainment and educational purposes. Overwhelmingly, the VCR is used as an entertainment technology rather than an information technology. Only 2.5% of respondents claimed to watch over 10 educational videos per month, while 19% claimed to watch more than 10 entertainment videos per month. There was no discernable difference between computer owners and non owners in regards to viewing educational tapes, but there is evidence that non-computer users are less likely to watch more than 10 videos a month than computer users.

The cellular phone can be used for personal communications, but because of its portability it is also a communications technology which can be used to disseminate and obtain information, and transmit and receive instructions. Only 39% of respondents owned a cellular phone. Of the 61% who did not own a cellular phone, 58% also did not own a computer. Of the 39% owning a phone only 40% did not own a computer. There may not be a reliable relationship between phone use and computer use as 28% of phone users purchased the phone in the past year, and over 49% had purchased the phone within the past 2 years. The cellular phone is not used to a great extent by farmers. 73% indicated that they use the cellular phone less than 30 times a month, or approximately once per day. Thirty percent use the cellular phone less than 10 times per month. In terms of expenditures on phone use, 68% of respondents state that the cost of using the cellular phone to them is less than $50/month, while only 11.4% claim spending more than $100/month.

Over 85% of respondents using a cellular phone claim that it is useful for conducting farm business, while only 14.6% find that the cellular phone is not much use on the farm. However, respondents also indicate that the cellular phone is much more useful for personal communications (83.3%) than business communications to suppliers etc. (72.1%).

An alternative, but dated, communications technology to the cellular phone is the 2-way radio. Over 56% of respondents who own a cellular phone also own a 2-way radio. Of those who own both a cellular phone and 2-way radio 61% use the radio on the farm and the cellular phone off the farm; 33% state that the cellular phone has replaced the radio on the farm, while 6% claim that they use both the radio and phone for on-farm use. The results indicate that while both technologies are employed, there may be a tendency for the radio to be substituted for a cellular phone. It is unlikely that the 2-way radio will become obsolete as the cost of full on-farm cellular communication may be prohibitive for some farmers.

Of those farmers who do not own a cellular phone, only 25.4% own a 2-way radio, and this group was evenly split between computer owners and non-owners. However of the 74.6% who do not own a 2 way radio, 45.5% also do not own a computer. Again, this may imply that some segment of the agricultural community is resistant to technology adoption.

Precision agriculture and Geographic Information Systems have been widely talked about in recent years. However, it does not appear that the adoption of GIS systems by farmers is wide spread. Only 1.2% of respondents use a GIS system on farm, and this group was evenly split between computer users and non users, as was the no GIS group. Although the 6 respondents who have a GIS system provide an indication that it is useful for planting, harvesting, and fertilizing, the number count is too low to make any reliable statements.

5.10 The Demand for Weather Information

Weather information and technologies is also important for farmers during the growing season, yet only 14.7% of respondents indicated that they own a dedicated weather radio, with slightly more computer users owning one , and slightly more non-computer users not owning one. Of those owning a weather radio, 60.7% use the weather radio at least once per day during the growing season, while 78.6% use it at least once per week.

The use of weather information was obtained by asking respondents the frequency by which they called local weather offices during the last growing season from a Public Recording, and how frequently they called for information for a specialist. Only 22.1% of respondents called at

least once per week, 11.2% called less than once/week, and 66.7% never called for recorded weather information. Likewise, farmers did not overwhelmingly use weather service specialists either. Over 88% of respondents did not call a weather specialist during the last growing season, while only 4.5% used such a service at least once a week.

Respondents were also asked the importance of various climatologic measures. The intent was draw a correspondence, or contradiction, between what farmers say is important, and how much they use weather services, and ultimately, how much they would be willing to pay for such services. The weather factors and responses are provided in Table 11:

In general farmers see weather information as being important. Precipitation and the drying index are considered very important by many farmers. Interestingly farmers find the chance of precipitation of being more important than the actual prediction of precipitation. Temperature, wind speed and daily Dewpoint are not considered as important by most farmers, although in general , about half of all farmers did consider this information as being relatively important.

Table 11: Importance of Weather Information

Factor	Very Important	Important	Not Important
Probability of Precipitation	62.4%	30.1%	7.5%
'Most Likely' Precipitation	37.4%	46.0%	16.6%
Maximum Daily Temperature	13.0%	52.7%	34.2%
Minimum Daily Temperature	18.0%	48.6%	33.5%
Wind Speed	19.3%	50.6%	30.1%
Drying Index	33.3%	46.9%	19.8%
Average Daily Dewpoint	10.7%	34.7%	54.6%

To what extent are farmers willing to pay for weather information. Respondents were asked to provide a value ranging from $0 per phone call to $4/phone call for a localized weather recording or a personal weather specialist. The results are provided in Table 12:

Table 12: Willingness to Pay for Weather Information		
Price ($/phone call)	Recorded message	Personal forecast
0$ / call	54.4%	60.0%
$0.50/ call	24.8%	16.2%
$1/call	13.1%	12.7%
$2/call	1.8%	4.0%
$3/call	.6%	1.2%
$4/call	0%	.2%
$5/call	1.0%	1.8%

While farmers find weather information important, they are not overwhelmingly in favour of paying for it. Over 54% of respondents would not pay for either a recorded message or personal weather information. While 24% would pay $.50 for a recorded message, only 16% would pay the same for a personal forecast. Still, the results indicate that farmers do place some value on weather information with over 37% stating that they would pay no more $1 or less for the recording, and 28.9% paying $1 or less per call for personal weather forecast.

The sample frequencies itemized above were used to estimate the demand elasticity for weather price information. The estimated price elasticity of demand was 1.65 for a recorded message, however the r- square was low at only .481, which indicates that price changes explained less than half the variation in demand for weather information. This indicates an elastic demand for weather information. An elastic demand usually indicates that total revenue can be increased by decreasing the price for the good or service, but given a price range starting at $0, $0.50, $1.00, there may not be much room for price variation.

5.11 Section Summary

This section has summarized key results from a telephone survey of over 500 commercial farmers from across Canada. Results show that about half of all farmers now own computers with a significant rate of adoption observed since 1994. Farmers are still reluctant to use the computer for management purposes other than accounting and record keeping, but this may be more a function of the availability of software and support than an unwillingness to use the technology in practice. Even so, most farmers who do own computers use it for some form of management purpose. It was also shown that the computer is used for more than farm purposes. The computer decision may well be based on the educational and entertainment needs of the family. Unlike many small businesses, the farmer adoption behaviour must also include family considerations.

There appears to be some resistance to information technologies by farmers. Farmer use of on-line services for market information is very low, with only 8% of respondents with computers actually using Internet providers. However, the demand for information technology is very

inelastic. These results indicate that for those farmers who do receive value from the information services, the value is likely much higher than its cost. However, many more farmers do not perceive any value from the information. This is in contrast to the demand for weather information, which being elastic, exhibits a larger market potential, but at lower price levels.

The survey also provides some evidence of technological resistance by some farmers. In most cases farmers who did not adopt computer and information technologies, did not adopt other technologies such as VCR,s , cellular phones, GIS systems, or weather radios. Although this group is smaller than the overall group that does not yet own a computer, the proportion is consistent with those farmers who do not own a computer and state that they unlikely would do so.

The study also confirmed specific hypotheses regarding scale of operation, age, and education. In general, younger farmers with more than high school education, and having gross sales over $100,000/year were more likely to use computer and information technology than those in the opposing groups.

6.0 AGRIBUSINESS USE OF INFORMATION TECHNOLOGY

Over 50 individuals were interviewed at 40 agribusiness firms, organizations, associations, and agencies. Technology use ranged from firms who did not use computers at all, to leading edge, state-of-the-art applications of interactive transactions using the Internet. The majority of firms were some place in between the extremes. Even though the range of use of new information technologies was very broad, certain commonalities emerged.

6.1 Use of Computers

Almost all firms interviewed used computers for accounting purposes such as payroll, accounts receivable/payable, etc. The actual systems used ranged from desk-top PCs to an 18 year old micro-computers, depending on the size and nature of the business. Firms were continually in the process of up-grading their systems. The few firms that did not have a computerized accounting system out-sourced their accounting function.

6.2 Electronic Communications (E-mail) In-house

Twenty-five firms had internal E-mail. Almost all multi-branch firms and all of the multi-nationals, banks, and the Wheat Pools/Board had in-house systems for regular communications. Types of E-mail included memos, company announcements, orders and inventory controls. The few medium-sized companies who did not have an in-house E-mail system were in the process of installing or at least developing their own system. The firms without in-house E-mail were small, and hence no real need for in-house E-mail. Switching from hard-copy memos to E-mail did not appear to be a problem once a system was in place.

In two cases it was not clear where the in-house stopped and the Internet began. The Wheat Pools/Board/Rail Roads have an extensive "in-house" system, with several nodes of the systems also linked with the Internet. Some individual stations may not currently be accessing the Internet, but they likely have the hardware to do so.

6.3 Electronic Communications (E-mail) External to Firm

More firms had in-house E-mail than external E-mail: 19 had external E-mail through the Internet, compared to 25 firms with in-house E-mail. However, several firms were considering getting on the Internet, in part for the E-mail services.

Internet access is required for external E-mail, but E-mail capability is not the same as Internet access to Web Sites. Several firms have used E-mail for years, but are just now getting the software to access the Internet. The hardware for E-mail and Internet access are the same, but the software is different.

6.4 Internet Access and Web Sites

Of the 17 firms reporting that they had Internet access, five currently had Web Sites, and 12 were in the process of developing their sites. All the firms thought that having a Web Sites was a good idea, but they were not sure what to put on their Web Sites, nor what the benefits would be to the company. In most cases the Web Sites was seen as a marketing tool. Information about the firm, its products, and ancillary information would be accessible at the Site. AGCO (formerly Massey Ferguson, Gleaner, and others) is further along than most companies in determining how to use their Internet Web Site. AGCO is collaborating with "Successful Farming" magazine and several other companies to put "Successful Farming" on the Internet as of April 1, 1996. AGCO hopes that interest in the articles posted by the magazine will bring readers to the Site, which will also have information about AGCO products. An analog to the concept is a shopping mall. AGCO will be equivalent to an "anchor store", but all companies collaborating at the Web Sites will benefit by proximity to each other.

Pioneer Seed's Web Site is being developed. They currently have an in-house Web Site for their 5000 employees world wide, and 305-310 farmer/sales representatives in Canada, 90% of whom have computers and are linked with the Pioneer system. Much of the same information on their in-house Site will be on the Internet Site: product descriptions and information, yield performance data, and publicly accessible information such as Agricultural Statistics. There will also be "Who is Pioneer Seed" section.

An issue for Pioneer is what type of information and how much should they provide for free on the Internet. Pioneer is 1/3 owner of Farm Data, a teletext/videotext or hardline information service. Information on futures markets, cash markets, weather, and general news is issued on either a real time or 10-minute delay. Providing access to this information through their Web Site would generate a lot of interest in Pioneer's Web Site, but doing so would be providing information for free that a subsidiary is in business to provide. The question of rival in use and excludability are very real when it comes to market information on the Internet.

Another issue is what should be "behind the firewall", i.e., private information, and how to insure that private information will remain private. Security of private information was important to several interviewees. Not only was private information an issue, but questions of possible harassment and even sabotage was a concern for at least one multi-national food company. Security issues are keeping several firms from accessing and using the Internet in their firms.

Five interviewees reported having access to the Internet at home, in part to evaluate its usefulness at work. Security was not an issue when no company information was kept on the home computer, and there was more time to "surf" to see what was available. The Internet may

be one of the first new technologies to gain greater use at home and then enter into business use. In previous technology cases, use was first in business, then in the home (e.g., computers, FAXs, phone mail).

All the interviewees commented on how slow the Internet is. Rather than a "Super Highway", it is more like a lane way. Access is only as fast as the slowest link, which in many cases is a copper telephone line. All the interviewees think that the Internet is evolving into something great, but that it is still in a rather early developmental stage.

Related to the Internet are electronic bulletin boards such as the FBMINet, which require a computer and a modem. These boards have had wide acceptance and use, but will likely soon fade away. Boards such as the FBMINet require the user to pay telephone charges to access a local server, and are usually downloaded once a day. In most cases, access to the Internet costs less, and has the added benefit of 24 hour/day real-time response. The FBMINet has registered thousands of hits, but the local servers expect to switch to a Web Site very soon. Moreover, no agribusiness had access to the FBMInet at their business, but three agribusiness managers did say they had accessed it through their home computers.

6.5 Teletext/Videotext Services

Teletext/videotext services refer to satellite up-link services such as DTN, Reuters, Global Link and Farm Data. All these services have similar information including futures markets, selected cash markets, weather information, and general news. Most are offered in two manners: a real-time services, usually priced around US$300/month, and a 10-15 minute delay at US$50-60/month.

Many firms had one of the information services listed above on a delay. Only grain traders and a hog-marketing board had the real-time services; the added cost of the real-time service is only economical when trading in large volumes on a minute-by-minute basis. Use of the information services was somewhat along commodity lines: all grain trading companies used an information service (usually real-time), half the beef and pork packing companies had a service, but none of the poultry processing companies had a service, real-time or delayed.

The firms without an information service tracked commodity prices on a daily basis, either through the "Blue Book" issued by Agriculture Canada, the "Yellow Sheet" from USDA, or the commodities section of a daily newspaper. As one VP-Procurement explained: his company was in the business of processing meat. Hourly price changes were of little importance. Long-term trends were important, and could be obtained by tracking the previous day's closing price.

As will be discussed later, information services companies will likely be out of business if their information becomes available on the Internet.

6.6 Electronic Data Invoicing and Other Business Transfers

Electronic data invoicing (EDI) is common among retailers and is becoming more common in the agrifood industry. The closer one is to the final retailer, the more likely that EDI exists. Examples of EDI include the Canadian Wheat Board using EDI for transactions with the provincial Wheat Pools, and most of the large, multi-national processors who deal with the major grocery distributors have EDI. Several processor also have EDI for input suppliers. At the other end of the marketing chain EDI is uncommon. No firms reported using EDI or any form of

electronic transfers when dealing with farmers. Most of the Internet connections are one way transfers of information. Banking appears to be leading the changes in electronic transfers on farms. The Royal Bank expects to have 24 hours/day, 7 days/week access to on-line banking services within a year, either through an on-line computer or telephone. The other banks are in the development or at least the planning stage of full electronic banking. The Royal Bank reports over 4% of their customers use telephone banking already, and within the year that percentage is expected to increase dramatically. The banks do not expect resistance to electronic banking -- most farmers use automatic teller machines (ATM) for current accounts, so changing to another type of automated transaction to another will not be a major change.

When asked about security problems with on-line computerized banking, one banker admitted that they expect more fraud with computerized banking than with ATM, but that fraud is just a cost of doing business. Problems will exist whatever the system, but the savings in time and expense for all parties with on-line banking are expected to be very large. Several input suppliers were asked about electronic transfers, either over the Internet or a similar on-line system, for ordering parts, deliveries, and other business transactions. The banks were the only input suppliers who expected most of their transactions to be electronic. Many firms will have Web Sites for information, but expect farmers will want to talk to a human for transactions. The experience of the banks may change this opinion.

A new information technology that was not considered at the start of this project is voice mail. All firms, and most farmers, have some type of voice mail, ranging from an answering machine up to a fully automated directory system. Several firms reported using some type of voice mail for making orders or for receiving orders. Given the ease with which verbal orders can be given or received, voice mail may have a bigger impact in day-to-day transactions than E-mail..

6.7 Government Information Services

The use and value of government information was largely dependent on type of business, commodity and location. For example, the beef and pork industries looked to Agriculture Canada for slaughter and price information. Grains and oilseeds and the dairy industry was similar; the industry provides data to the federal government, who then compile and release the information. Poultry and much of horticulture, particularly non-edible horticulture, have little interaction with government information services and do not appear to want to increase the level of interaction.

6.8 Cell Phones

Cell phones have quickly been adopted by salespeople, executives, and senior level managers. They are especially prevalent in the Prairies, where long distances between towns can mean travel time can be long. Business activities can continue even when in a car for extended periods with cell phones. The major expense associated with a cell phone is not the phone but the service required to use the phone. Several firms reported setting limits on cell phone use in order to keep operating expenses down.

A variation on the cell phone with implications for the processing industry is the Bell "Companion" system. It is a headset-with-microphone system that replaces intercoms, and allows calls to be directed to managers anywhere within a plant. In effect, the system gives managers more time to manage, as less time is spent walking to a telephone.

All firms interviewed agreed that operating costs of cell phones will need to be comparable to on-line telephones before the on-line phone is fully replaced by a cell phone.

6.9 Videos

Firms reported using videos in a number of ways. Several firms use in-house videos for training. These videos range from low quality, rather home-made videos that demonstrate a particular skill or technique, to high quality, professional done training videos. Videos are also used for marketing and promotional activities. A veteran marketing manager suggested that the video has replaced the photograph for situations where a picture is either required or preferred. As such they are used in many different situations.

6.10 Geographical Positioning (Information) Systems (GPS or GIS)

GPS refers to a system where a very accurate positioning system is combined with a yield monitor on a harvester to obtain yield data on a square meter or smaller basis. Such systems have been used in Europe for a few years, but are still very new in North America. All major agricultural equipment manufactures either have a GPS on the market, or expect to have one soon. The systems were first developed to help manage variable rates of fertilizer, but may have other uses as well. The output of the system can be put on a map to visually report the yields from any field. One producer said an analogy is the Dairy Herd Improvement information allows a dairy producer to see how the cows are doing, but without having to be in the barn. GPS allows a farm manager to see how the fields are doing, but without having to be on the tractor at harvest time.

The benefits of GPS is still uncertain. All the manufactures admit that the benefits will likely come after three to four years of monitor a field, and only custom operators who will have yield maps for their customers will benefit in the short run. However, at least one manufacturer expects excess demand for his systems this spring.

6.11 Other New Information Applications

The new information technologies are made possible in large part by the microchip, which is impacting the agrifood industry in ways other than those already mentioned. One important application is in linking microprocessors to sensors in livestock production processes. By identifying individual animals and computerizing feed mixing, feed rations are being customized at the individual animal level. Such systems minimize waste, increasing efficiency and lowering costs. Dairy herd production monitoring, which has been done by the Dairy Herd Improvement Associations and Corporations (DHI) can now be done on-farm with systems incorporated into either pipe-line or parlour milking systems. Information which DHI used to share freely with other DHI units and breeding centres for genetic analysis may soon be collected, stored and analyzed on the farm. Not sharing production information may have implications for the breeding industry and the genetic progress of the dairy herd.

Similar concerns about on-farm collection of production information was voiced by government agencies whose mandate is to collect and disseminate cost of production data. Micro-computers and other new information technologies may make the collection and analysis of farm production data easier for the farmer, but unless that data is in some way shared, the gains that have been made through cost of production comparison may be at risk.

6.12 Personal Networks

Throughout the interviews the importance of personal networks kept being mentioned. Even managers who had Internet access and regularly E-mailed around the world stressed that personal networks were their most important source of information. The new information technologies, in particular the Internet and E-mail, will likely complement the establishment and maintenance of personal networks.

The VP of a large processing firm gave an example of the importance of personal networks and how new information technologies enhance those networks. Researchers in the Canadian agrifood industry register research projects on the ICAR system, which is accessible on the Internet. Theoretically, it is possible to locate researchers working on leading edge technologies in agrifood through the ICAR. The VP has tried to use the ICAR to follow what research is happening, and to locate researchers when he had a specific question. He has found, however, that networking through conferences and personal contacts keeps him better informed of who is doing what. Once the contacts are made, E-mail, FAX and cell phones make it much easier to maintain the contacts.

7.0 GOVERNMENT INFORMATION SOURCES

Three aspects of government information emerged from interviews with agribusiness firms and government agencies: i) government information systems are for the most part ad hoc; ii) the nature, structure and conduct of the ad hoc system depends on which commodity is in questions; and iii) the greater the level of government involvement in a commodity's market, the more involved is a government agency in gathering and disseminating data about that commodity's market.

There may be disagreement as to the ad hoc nature of government information sources, given the formal institutional structure of the Canadian Grain Commission and the Canadian Dairy Commission, both of which closely monitor their industries and release reports on a regular basis. However, data gathering for other agriculture industries is much less structured. For example, both the hog industry and the dairy industry provide price and quantity data to the government. Cost of production in the dairy industry is monitored by a consortium of Federal, provincial and industry agencies, with input from academia. The pork industry, on the other hand, has cost of production data gathered on a year-to-year contract basis. Both industries are important, the COP figures are quoted throughout the industry, but there is no formal institutional structure to maintain the COP figures for the pork industry.

If one arranged Canadian agriculture industries on a scale from highly regulated (e.g., the dairy industry) to almost no government regulation (e.g., non-edible horticulture), the degree of government involvement with gathering and disseminating data about the industry would closely follow the level of government regulation. In the interviews with government agencies there was an awareness that the role of government in gathering and disseminating information was changing, but in what way is not clear. Greater use will be made of the Internet in disseminating information; the cost of dissemination will be close to zero once mounted at a Web Site. However, there are positive costs in gathering, screening and editing data into information for those Web Sites. Given the growing acceptance of "user pay", it is very likely that commodity groups will have to take a greater role in the gathering, disseminating and maintaining data and information about their industry. Where commodity groups once took the initiative in lobbying

governments to provide information services, those groups may have to provide those services themselves.

8.0 SUMMARY AND CONCLUSIONS

The purpose of this study is to analyze the economics of new information technologies within the agricultural sector in Canada. This study has three components to meet this goal : i) a review of the literature, ii) a survey of Canadian farmers, and iii) interviews with agribusiness firms and government agencies. This final section summarizes the findings from those three components and presents conclusions from the analysis.

8.1 Summary of the Literature Review

The review of papers on the economics of information with respect to agriculture and the adoption of new information technologies on the farm identified the following major themes:

* Information is both an input in production and a product of a functioning market. As such, it has many aspects.
* Information has value when it affects prior beliefs and or actions. Information acquires value by enabling people to more effectively see the means at their disposal to achieve their goals. It can also make people more aware of entrepreneurial opportunities.
* Information can be a public good, i.e., non-rival in consumption, but rival in delivery and commercial use.
* Economics of information can not be separated from subjective perceptions of risk and uncertainty. Moreover, economics of information is closely tied to agency problems or transactions costs of moral hazard, adverse selection, and the transaction costs of search, negotiation, and enforcement.
* Lack of perfect information does not indicate a market failure.
* The information and transaction sectors in modern economies is estimated at approximately 50% of GDP.
* Information impacts production agriculture by affecting the economic quantity and timing of inputs and activities, ranging from quantities of fertilizer, timing and quantity of irrigation, and the timing and efficacy of both risk reducing and production enhancing inputs.
* Farmers obtain information from a broad range of sources, including media and personal networks.
* USDA price forecasts are not significantly different than futures market prices, but there is some evidence that USDA (and other government market information) speeds price discovery and hence decreases deadweight losses due to out-of-equilibrium markets.
* Adoption of new technologies usually follows an 'S'-shaped curve of early, middle and late adopters, but studies of computer use reports more of a straight line adoption curve.
* Studies of computer adoption and use on the farm were done in the 1980's, but rarely in the 1990's.
* "Expert" systems and other integrated computer information systems are mostly used and evaluated on experiment stations and university farms, rarely on commercial operations.
* Computers are adopted by younger farmers who manage larger, more diversified operations.

* There is some worry that new information technologies may contribute to a widening gap between the "haves" and the "have nots" of information.

8.2 Summary of the Farmer Survey

The survey of 502 Canadian commercial farmers (i.e., farmers reporting farm incomes of at least $50,000/year) reported the following results:

* About 50% of all commercial farmers have computers, with half of those computers purchased over three years ago, the rest purchased equally over the last three years.
* Among farmers without computers, cost and lack of need (33% and 32% respectively) were the reasons most cited for not having a computer. Other reasons included complexity (9%) and lack of training (9%). Lack of software (2%) was not an important deterrent to computer use.
* Younger farmers with more education and larger operations were more likely to have a computer. Enterprise type does not appear to affect the use/non-use decision.
* Major considerations when purchasing a computer included use for farming (84%), non-farm work (76%), and education (88%). Use for household records or decision was not a consideration for 56% of those surveyed.
* Computers are used primarily for keeping general farm accounts, and much less for enterprise analysis, budgeting, payroll, and as a decision aid.
* Computers have helped farmers to keep more detailed records, produce financial reports, and know and analyze financial performance more precisely, but most farmers do not think that computers have changed the way they manage their businesses.
* Less than 7% of the farmers surveyed use satellite broadcast information service or agricultural bulletin boards, 9% are on the Internet, but the attrition rate is very high. For both the information services and the bulletin boards, 4% have used them in the past but no long do so, and 5% have used the Internet in the past.
* Approximately 60%-70% of the farmers surveyed were willing-to-pay for the ability to electronically communicate with their banker, accountant, suppliers, etc., obtain market information or market forecasts. Slightly less than half were willing to pay for weather forecast information.
* The elasticity of demand for market information is inelastic, in the -0.11 to -0.12 range; the demand for weather forecast information is elastic (approximately -1.65).
* Video Cassette Recorders are considered an entertainment system rather than an information system. VCRs were reported by 88% of the farmers, with only 2.5% reporting use of educational videos.
* Cell phones are used by 39% of the farmers. While 72% of the cell phone users say their phone is useful for business communications, 83% said that it was more useful for personal communications.
* Only 1.2% (6 farmers) reported having a Geographical Information System.
* Farmers rank weather information as very important, with probability of precipitation the most important type of information.

8.3 Summary of Agribusiness and Government Agency Interviews

Various agribusiness firms and government agencies were interviewed. Common issues, trends and insights emerged from the interviews.

* Agribusiness firms used computers for accounting, inventory, and in-house E-mail. More firms have E-mail in-house than externally, but most firms are moving towards Internet links, which will allow for external E-mail.
* Many firms have Web Sites, many more firms are planning and/or developing Web Sites, but the costs,benefits and implications of Web Sites are uncertain.
* Calling the Internet a "super highway" is a misnomer. Most users find it slow, cumbersome and not clearly marked.
* Several managers are evaluating the Internet at home for possible business use. Security is a concern for many; i.e., keeping private information "behind the firewall".
* Information services such as DTN, Global Link, Reuters and others may be forced out of business by companies providing the information carried by those services as part of a Web Site public service.
* Real-time market information is used only by large-volume traders. Most firms are satisfied with delayed-time information or even the previous day's closing price.
* The more government involvement with a market, the greater the amount of government involvement with information about that market.
* Electron Data Invoicing (EDI) is common among retailers and is moving down the marketing chain at the request of those higher in the chain.
* Banks appear to be leading the way in establishing electronic communications with customers. Many banking transactions are done on telephone, and will soon be done through computer links.
* Cell phones and videos are ubiquitous among sales and marketing people. Their use will likely increase.
* Geographic Positioning (Information) Services (GPS) are still very new. The benefits of GPS are still uncertain, but are expected to include more precise fertilizer and other chemical input use, and precise yield monitoring.

8.4 Conclusions

Several conclusions emerged from the literature review, the farmer survey and interviews with agribusiness firms and government agencies.

8.4.1 A Theory of Information

The literature and interviews with firms indicate that the value of information is highly subjective. Theoretically, information can reduce uncertainty and has value if it affects prior beliefs and/or actions. Individuals have unique prior beliefs, hence Hilton's idea that information be valued by the change in utility relative to the cost of obtaining that information. It is difficult to objectively value information. Bids for information may be observed, but the utility obtained from information can be revealed but not measured or compared. The value of information can at best be approximated by observing how information affects actions, or through direct elicitation.

Information is both an input and an output, depending on if one is using information or producing information. It may be rival in production and distribution, but non-rival in consumption, which has implications for the proper role of government in providing information.

8.4.2 The Use of Computers on the Farm and in Agribusinesses

The survey of farmers reported that younger farmers with larger operations and more education were also more likely to use a computer in their farm business. This finding is consistent with

previous studies. Possibly more important that the percentage of farmers using computers is how those computers were used. Computers on farms are used primarily for keeping general farm accounts; in effect, increasing the speed and accuracy of monitoring the finances of the farm business. Using computers in a planning function was reported much less; using a computer for "what if" questions and decision aid programs were reported by less than half the farmers.

Given the increasing size and complexity of farms in Canada, and a continuing increase in education levels, the percentage of farmers using computers is expected to increase. The adoption rate for computers may be more linear than usual "S-shaped" adoption rate curve identified for other new technologies.

The use of computers on the farm is expected to contributed to increased managerial effectiveness. If the role of the manager is to plan, direct, monitor and control the farm operation, then computers can increase the speed and hence lower the cost of monitoring the farm business. The low rate of "what if" questions and other planning applications with computers may increase as more farmers become familiar and comfortable with computers and their capabilities through keeping accounts and other farm records.

The use of computers among agribusiness is common; it would be uncommon to find an agribusiness without computer maintained accounts and records. As with non-agriculture sector businesses, computers have already been widely adopted.

8.4.3 Use of Internet and Web Communications on Farms and Agribusinesses.

The Internet is still being tested by the leading edge innovators. There may be 9% of the farmers on the Internet, but an additional 5% have tried it and found little reason to stay with it. A chain is only as strong as its weakest link, and the Internet is only as fast as the modem and copper wire connecting the farmer to the world. Many Internet users find the Net slow and not reliable. This may be a minor technical problem that will be soon solved.

The type of information on the Internet is at best mixed. The firms interviewed either had a Web Site or were developing a Web Site, but few firms have any idea of what should go on their Site. Some firms are thinking of putting market and weather information on their Web Sites as a public service for their customers. Given the few firms that use real-time market information, a Web Site with agricultural market information would strongly impact the information services who currently charge up to US$60/month for such information.

Approximately 60% of the farmers surveyed were willing to pay for the ability to electronically communicate with their banker, accountant, input suppliers, etc., and obtain market prices and forecasts. These farmers exhibited an inelastic demand for such market information and electronic communications services. For these farmers, and likely for many agribusinesses, information is a necessary input. A farmer or a grain trader handling large volumes can make (or lose) a sizable amount of money by knowing (not knowing) what the market is doing in a timely manner. On the other hand, a farm or business with a small operation may not have the volume to make a difference on a quick trade.

All the agribusinesses interviewed were aware of the great potential of the Internet, but no one had any idea of how that potential was to be realized. The banks are furthest along implementing electronic businesses transactions; all banking transactions will be able to be

completed electronically in a matter of months. In effect, these electronic transactions are extensions of automated teller machines. Whether other business follow suit is unknown at this time. One agribusiness firm expects their Web Site on the Internet to provide product and price information to customers, but thinks that farmers will want to talk to another person when it comes to transactions.

The Internet may be the first new information technology to be first in the home and then later in the office. Computers, facsimiles, and E-mail were all used in offices before they became common in houses. The adoption of the Internet appears to be in reverse order: home first then office. The place of adoption may have implications as to the recreational versus business use of the Internet, but the Internet is so new that any predictions about it are likely to be wrong.

The teletext/videotext systems (e.g., DTN, Reuters) and electronic bulletin boards (e.g., FBMInet) are expected to decrease in use as the Internet increases in use and information available on it. Cost and interaction versus batch processing are the two primary reasons. The cost of the Internet in most cases is a telephone charge. Farmers on party lines have problems with Internet access, and most rural users have to pay long distance charges, but party lines are being replaced by single-user lines, and local Internet servers are starting to make Internet access a local phone call. The Internet is interactive, while electronic bulletin boards rely on batch processing: a single call to send and receive messages. The increased timeliness of an interactive system is expected to decrease the use of the bulletin boards.

8.4.4 Use of Cell Phones by Farmers and Agribusinesses

A casual hypothesis of this study was that cell phones are replacing 2-way radios on farms. Cell phones are becoming common both on and off the farm, but there were no indications that radios are becoming obsolete. It is likely that as radios wear out they will be replaced with cell phones, but working radios are not being salvaged and replaced by cell phones. The vision of everyone having their personal phone where ever they are may soon be reality. The impact to agriculture is expected to be similar to that of society in general; i.e. instant access to communications.

8.4.5 Use of Video Tape Systems by Farmers and Agribusinesses

Farmers use video tape systems primarily for recreational purposes. Both farmers and agribusinesses use video tapes for training and marketing purposes. The impact of video tapes, similar to cell phones, is on society in general and not expected to have a unique impact on agriculture.

8.4.6 Use of Global Positioning (Information) Systems (GIS)

Only six farmers reported using a GIS. The agribusinesses involved with GIS expect the demand to exceed the supply in the next year or so, but neither farmers nor agribusiness are completely clear on the benefits of the system. The systems are so new and so few farmers are using them that no analysis can reliably be done on their expected impact. However, two anecdotes may provide insight about GIS.

The agribusinesses said that GIS was developed for precise fertilizer and chemical applications. Users may find other reasons for GIS. One farmer said that he is using GIS to monitor his fields without having to be on the tractor. His GIS provides a map of his fields with yields by 10 metre

square areas. From this map he can tell where a tile drain may be clogged and similar field conditions. He says that he wants to know his field conditions, but his time is more valuable in the office than on the combine. Another farmer, having recently bought a GIS, said that she did not know how she was going to use the information it provided, but that trying new technology as it was developed had always benefited her in the past.

8.4.7 The Role of Government and New Information Technologies

The role of government agencies in providing information is an important policy question. In those markets in which government intervenes or closely regulates, there is also a lot of government information provided, and industries with little government involvement there is at most ad hoc government information series. The dairy and hog sectors are examples of this relationship between government involvement and information. The Canadian dairy sector is highly regulated at both national and provincial levels through government legislation. Government is also closely involved with gathering, screening and disseminating information about the dairy sector. For example, in Ontario annual cost of production information is gathered and released through a co-operative arrangement with the Canadian Dairy Commission, Dairy Farmers of Ontario and the University of Guelph. The other provinces have similar systems for monitoring the cost of production. Milk and milk product disappearance is also closely monitored. The hog sector, on the other hand, has little government regulation compared to the dairy sector. Government monitors slaughter and disappearance through government inspections, but cost of production information is gathered on an ad hoc basis: currently hog cost of production in Ontario is monitored on a year to year contract basis. If government involvement in market continues to decrease, it would be reasonable to expect government involvement with information on those markets to decrease also. However, there may still be a role for government in the information systems.

In many industries government screens and edits data obtained from the industry group or association, and then disseminates information. The government has an important role as an "honest broker" of that information. Information about quantities, quality or prices from a competitor may be suspect; intentionally misleading information could be given to competitors to disrupt their strategies. However, data that has been screened, edited and disseminated by government should be accurate and above suspicion. Hence, this role as an "honest broker" of information is an important role for government agencies.

An important question is whether government should charge a user fee for information. Given that once the data is screened and edited the information is non-rival and non-excludable, the information has the characteristics of a public good. User fees may be problematic. If user fees are problematic, the question is whether government should continue to provide the information series, or depend on industry to see to its own information needs? The role of "honest broker" may be sufficient for industry to support the role of government in the provision of information.

An argument for government to continue to provide information as a public good is that agricultural information increases price discovery and hence market efficiency is increased. However, previous studies have indicated only a weak significance that USDA outlooks add information not already in the market from other, private sources. The benefits of market information occur to those active in the market, much less to society in reduced deadweight loss. Hence it is reasonable that the markets take responsibility for providing information about themselves.

If electronic communications expand as everyone predicts, it is reasonable to expect producer and commodity groups to provide and maintain market information as a benefit to those in the industry. Once screened and edited, information is non-rival and non-excludable, similarly to TV and radio broadcasts. The companies that are currently developing Web Sites are trying to determine what should go on their Sites. Many of those firms expect to provide information the will benefit their customers. The bottom line is that much of the information that will benefit farmers and firms in the agriculture sector will be provided by firms and producer and commodity organizations as soon as fast, reliable systems are developed and in place.

8.4.8 The Impact of New Information Technologies -- A Last Word

In most cases, more information is preferred to less. The new information technologies are expected to increase the amount of information available to all levels of the agrifood system, the ease of access to that information and the speed at which the information is delivered. These new technologies are expected to enhance the managerial ability of the agrifood system and increase the speed at which the agrifood system can respond to the changing tastes and preferences of consumers world wide. As with most new technologies, early adopters will benefit more from the new technologies than will the late adopters. There will likely be information "have-nots" who will be left behind by the information "haves" who adopt the new technologies and reap the benefits. Society in general, however, is expected to benefit from the new information technologies.

REFERENCES[7]

Ahituv, N., 1980. "A Systematic Approach toward Assessing the Value of an Information System". *MIS Quarterly*, 4(4):61-75.

Akerlof, G. 1970. "The Market for Lemons". *Quarterly Journal of Economics*, 84(August): 488-500.

Berger, P., J. Kobielus and D. Sutherland, editors . 1988. *Measuring Business Value of Information Technologies*, ICIT press, International Center for Information Technologies, Washington, D.C.

Bishop, Richard C. and Thomas A. Heberlein. 1990. "The Contingent Valuation Method." in Economic Valuation of Natural Resources, ed. by Rebecca L. Johnson and Gary V. Johnson. Boulder, Colorado: Westview Press.

Brookshire, D.S., M.A. Thayer, W.D. Schulze and R.C. d'Arge. 1982. "Valuing Public Goods: A Comparison of Survey and Hedonic Approaches." American Economic Review, 72:165-77.

Caspari, J. A. "Fundamental Concepts of Information Theory." Managerial Accounting, 49(1968):8-10.

Clearfield, Frank and Paul D. Warner. 1984. An Agricultural Videotext System: The Green Thumb Pilot Study. Rural Sociology. Summer. 49(2): 284-297.

Coase, R. 1937 "The Nature of the Firm" *Economica*, 4(November):386-405.

Coase, R. 1960. "The Problem of Social Cost" *Journal of Law and Economics*, 3(October):1-44.

Dahlman, C. 1979. " The Problem of Externality" *Journal of Law and Economics*, 21(1):141-162.

Demsetz, H. 1969. " Information and Efficiency: Another Viewpoint" *Journal of Law and Economics*, 12(1):1-22.

Dillman, Don A. Mail and Telephone Surveys: The Total Design Method. John Wiley & Sons, New York, 1978.

Griliches, Zvi. 1957. "Hybrid Corn: An Exploration in the Economics of Technological Change." Econometrica, 25(3):501-522.

Green, P.E., P.J. Robinson and P.T. Fitzroy. 1967. *Experiments on the Value of Information in Simulated Marketing Environments*, Allyn and Bacon, Boston.

[7] These general references are supplementary to the annotated bibliography "The Value of Information and the Value of Information Technology: An Annotated Bibliography with References to Agriculture"

Hanemann, W. Michael. 1984. "Welfare Evaluations in Contingent Valuation Experiment with Discrete Responses." American Journal of Agricultural Economics, 66(2):333-41.

Hayek, F. .1945. "The Use of Knowledge in Society" *American Economic Review*, 35(4):519-530.

Hess, J. "Risk and Gain from Information." Journal of Economic Theory, 27(1982):231-238.

Hirshleifer, J. 1971. The Private and Social Value of Information and the Reward to Inventive Activity. *American Economic Review* 61(4):561-574.

Howard, W. H. and G. L. Brinkman. "Identifying Management Differences Between Farmers in Canada." Canadian Farm Business Management Council, Ottawa, August 1994.

-------, and R. MacMillan. "In Search of Excellence on the Farm: An Example of Case Research." Agribusiness: An International Journal, 7(1991):1-10.

Just, R.E., D. L. Heuth and A. Schmitz. 1982. Applied Welfare Economics and Public Policy. Prentice-Hall, Englewood Cliffs, NJ.

Kirzner, I. 1973. *Competition and Entrepreneurship*, University of Chicago Press, Chicago.

Kirzner, I. 1985. *Discovery and the Capitalist Process*, University of Chicago Press, Chicago.

Kirzner, I. 1989. *Discovery, Capitalism and Distributive Justice*, Basil Blackwell, Oxford.

Knight, F. 1921. *Risk, Uncertainty and Profit*, University of Chicago Press, Chicago.

Laver, M. 1989. *Information Technology: agent of change*, Cambridge University Press, Cambridge.

Marschak, J. "Economics of Information Systems." Journal of the American Statistical Association, 66(1971):1-18.

Mitchell, R.C. and R.T. Carson. 1989. "Using Surveys to Value Public Goods: The Contingent Valuation Method." Resources for the Future, Washington, D.C.

Mukhopadhyay, T. 1988. *Evaluation of Management Information Systems: A Microeconomic Approach*, Ph. D. Dissertation, University of Michigan, Ann Arbor.

National Academy of Sciences .1987. *Technology and Employment Innovation and Growth in the U.S. Economy*, National Academy Press, Washington, D.C.

Plant, R., F. Gregory and A. Brier, editors, .1988. *Information Technology: the public issues*, St. Martin's Press, New York.

Robison, L. and P.J. Barry .1987. *The Competitive Firm's Response to Risk*, MacMillan, New York.

Samuelson, Paul A. 1954. "The Pure Theory of Public Expenditure." Review of Economics and Statistics, 36(4):387-89.

Sellar, C., J.R. Stoll and J.P. Chavas. 1985. "Validation of Empirical Measures of Welfare Change: A Comparison of Nonmarket Techniques." Land Economics, 61:156-75.

Simpson, R. and I. Simpson, editors, . 1988. *High Tech Work*, Research in the Sociology of Work: a Research Annual, Volume 4, JAI Press, Greenwich, Connecticut.

Stigler, G. "The Economics of Information." Journal of Political Economy, 69(1961):213-225.

Statistics Canada, (1994). Canadian Agriculture at a Glance, Catalogue 96-301, October.

Stigler, G. 1961. "The Economics of Information",*Journal of Political Economy*, 69(June): 213-225.

Thayer, M.A. 1981. "Contingent Valuation Techniques for Assessing Environmental Impacts: Further Evidence." Journal of Environmental Economics and Management, 8:387-401.

Tye, Eugenia M. W. Ng, and Patrick Y. K. Chau. 1995. A Study of Information Technology Adoption in Hong Kong. *Journal of Information Science*. 21(1): 11-19.

Waldie, Bruce. 1989. "Accounting Software: The Answer to Better Farm Records?" *Canadian Journal of Agricultural Economics*, 37(4):727-732.

Wallis, J.J. and D. C. North (1986) "Measuring the Transaction Sector in the American Economy, 1870-1970" in *Long Term Factors in American Economic Growth*, edited by S. L. Engerman and R. E. Gallman, University of Chicago Press, Chicago.

Yarbrough, Paul. 1995. Professor, Department of Communication, Cornell University, Ithaca, NY. Personal communication, December.

APPENDIX I.
Sources of articles on the economics of information, 1970-1995.

Journals to be Searched (Previous name):

Journal of Agricultural Economics
Agricultural Economics
Australian Journal of Agricultural Economics
Southern Journal of Agricultural Economics
Western Journal of Agricultural Economics
Northeastern Journal of Agricultural Economics
Farm Economist
Canadian Journal of Agricultural Economics
European Review of Agricultural Economics
Journal of Agricultural Cooperatives
American Journal of Agricultural Economics (Journal of Farm Economics)
Economic Perspectives
Review of Agricultural Economics (North Central Journal of Agricultural Economics)
Farm Management
Agronomy Journal
Agribusiness
Journal of Farm Managers and Rural Appraisers

On-line Searches:

Commonwealth Agricultural Bureau
Agricola Bibliography of Agriculture
Agrisearch
Sociofile

Search formatting:

1970-1995
Economics of information
Farm records
Computers in agriculture

APPENDIX II.
Farmer Survey

1. Do you currently have a computer?
   If NO COMPUTER
   Why don't you have a computer?
   - cost
   - too complicated
   - not needed
   - no useful programs
   - no training
   - other

   GO TO #10.A

   If YES

2. When was it purchased? Month/Year
   Approximate cost of the system when purchased?
   Kind of computer _____

3. 1st, 2nd, 3rd computer purchased?

4. When you first considered getting a computer, to what extent were each of the following a consideration? Please say whether it was (NOT) a consideration, (SOMEWHAT) Important, or (VERY) important consideration.

   - use for farming
   - use for non-farm work
   - use for household records or decisions
   - use in education of family members
   - use for learning how to use a computer.

5. To what extent is your computer used for the following applications. Please say either ALMOST NONE, A LITTLE, QUITE A BIT, or A LOT.

   i) to keep general farm accounting records(e.g., income and expenses).
   ii) to keep enterprise accounts (e.g.,separate records for a corn crop or a hog operation).
   iii) for tax preparation.
   iv) to keep inventory and/or depreciation records (e.g., machinery, fertilizer, feed, etc.).
   v) to establish a budget for my operations and monitor actual vs. Budgeted income and expenses.
   vi) to manage payroll.
   vii) to run decision-aid programs for management (e.g., ration balancing or cropping options).
   viii) to run crop or livestock management programs to keep detailed production records on these operations.
   ix) to do word processing for the farm business.

6. Approximately how many hours a week does your family spend on the computer for:

farm/business work
off-farm business
educational uses
recreation/entertainment
personal use

7 Please say whether you STRONGLY AGREE, AGREE, DISAGREE, or STRONGLY DISAGREE, or have NO EXPERIENCE with the following statements about how your computer has affected your farming operation.

i) I keep much more detailed farm records now that I have a computer.

ii) My computer really has not changed the way I manage my farm.

iii) The ability to produce immediate financial reports is one value in using a computer.

iv) The computer's ability to calculate answers to number "What if .. ? type questions has made money for me.

v) Using a computer has helped me identify problems and opportunities in my farm business which were not obvious before.

vi) Keeping farm financial records with a computer really seems to be more trouble that it is worth.

vii) The computer allows me to know my financial affairs and analyze business performance more precisely than was possible without it.

viii) Using a computer has allowed me to expand my farming operations and still manage them effectively.

ix) Although I do not use my computer for farming, I find I keep records and make decision in about the same way I did before I got it.

8. When you consider the costs associated with your purchase and use of your computer (that is, equipment, software, training, maintenance, etc.) and balance these costs against the benefits you derive from its use, which of the following statements best describes the net gains or losses from your computer use?

a substantial net gain
a modest net gain
no gain or loss
a modest net loss
a substantial net loss

9. For the following agricultural information services please say whether you are I) currently using them, ii) have used it but are not using it now, or iii) have never used it.

If iii) HAVE NEVER USED IT, GO TO # 10.B.

a. DTN (formerly called Dataline), Reuters, or another systems that requires a special device to receive FM sideband or DBS Satellite signals on a monitor?

b. SCAMP,Agridata,Instant Update, FBMInet, or another interactive computer database system which you access by your computer and a modem.

c. Compuserve, America On-Line, or another Internet/WWW which requires a computer and a modem, and allows access to E-mail and electronic bulletin boards.

If ii) HAVE USED IT BUT NOT USING IT NOW,

d. Why?
Cost
Not useful
Too Much Trouble
Other

GO TO # 10.b

10.A Suppose you could use a computer to communicate with your banker or accountant to check balances, or with an input supplier to check prices or to order inputs and deliveries, and other business transactions. Such a system would use the Internet, World Wide Web, E-mail, or a similar system. Would the availability of such a service make you be MUCH MORE LIKELY, MORE LIKELY, or NOT VERY LIKELY to buy a computer?

GO TO # 11.

10.B Suppose you could use your computer to communicate with your banker or accountant to check balances, or with an input supplier to check prices or to order inputs and deliveries, and other business transactions. Such a system would use the Internet, World Wide Web, E-mail, or a similar system. Would you be willing to pay $5, 10, 15, 20, 25, 30/month for such a system?

11. Using an on-line computer system described above to communicate with other businesses:

i) Would you be willing to pay $5, 10, 15, 20, 25, 30/month for current futures prices (e.g., livestock and commodities prices on the CBT, Mercantile Exchange, etc.)? Y/N.

ii) Would you be willing to pay $5, 10, 15, 20, 25, 30/month for current grains, oilseed and/or livestock cash prices in each of your local, regional, and North American markets? Y/N

iii) Would you be willing to pay $5, 10, 15, 20, 25, 30/month for forecasts of grain, oilseed and/or livestock prices 3 months from now? Y/N

12. Do you own a video tape player (VHS player)?
If YES -- In an average month, how many tapes do you play for Entertainment? Education/instruction?

13. Do you own a cellular phone?
If NO, GO TO # 16
If YES
When did you buy it?
How much did it cost -- to buy _____ to operate _____
1st, 2nd, 3rd one bought?

14. Please rank the following uses of your cellular phone by VERY USEFUL, USEFUL, NOT USEFUL.
I) on-farm communications
ii) stay in-touch with suppliers, buyers, other businesses.
iii) personal use

15. Do you have or have you ever had a 2-way radio for on-farm communications?
IF YES --Which of the following best describes you:
I) We use the radio on-farm and the cell phone for off-farm.
ii) The cell phones have replaced the radio
iii) Other

GO TO # 17

16. Do you currently have a 2-way radio for on-farm communications? Y/N

17. Do you own a Weather radio designed specifically to receive frequencies carrying weather forecasts issued by Environment Canada?

a) yes
b) no

IF YES:

18. How often do you use your Weather radio during the growing season?

a) more than once per day
b) once per day
c) several times per week but less than once per day
d) once per week
e) less than once per week
f) not at all

19. How often did you telephone your local weather office during last years growing season to obtain weather forecast information from the public weather recording?

a) more than once per day
b) once per day
c) several times per week but less than once per day
d) once per week
e) less than once per week
f) not at all

20. How often did you telephone your local weather office during last years growing season to obtain weather forecast information directly from the office weather specialist?

a) more than once per day
b) once per day
c) several times per week but less than once per day
d) once per week
e) less than once week
f) not at all

21. For the following weather variables rank the importance of their forecast on your operation as either VERY IMPORTANT, SOMEWHAT IMPORTANT or NOT IMPORTANT.

	Very Important	Somewhat Important	Not Important
Probability of Precipitation			
Most Likely Precipitation Amount			
Maximum Daily Temperature			
Minimum Daily Temperature			
Wind Speed			
Drying Index			
Average Daily Dewpoint			

Environment Canada currently produces specialized farm weather forecasts for the agricultural community. This forecast is available 24 hours per day and is updated three times per day. Individual forecasts are provided for specific counties or regions. The forecast contains a synopsis, outlining what weather conditions can be expected over the next 48 hour period. It also includes forecasts for a wide range of weather variables including temperature, precipitation, drying index, average daily dewppoint, and wind speed and direction. This forecast can be obtained by calling your local weather office and listening to an automated phone recording or by speaking with the weather specialist at the weather office. The weather specialist can answer any questions the call may have as well as providing the caller with more detailed information if so desired.

22. Would you be willing to pay $0.50, 1.00, 2.00, or 4.00 per phone call to receive farm weather forecast information from a weather recording at your local weather station?
YES/NO

23. Would you be willing to pay $0.50, 1.00, 2.00, or 4.00 per phone call to receive farm weather forecast information from a personal weather specialist at your local weather station?
YES/NO

24. Do you have a geographical positioning system (GPS or GIS) on any of your field equipment?
IF YES -- Please rate how useful the system is by say VERY USEFUL, SOMEWHAT USEFUL, NOT VERY USEFUL, or DON'T KNOW YET.

i) on planters
ii) on combines/harvesters
iii) for fertilizer applications

25. Farm and farmer characteristics (confidential) . .
i) sex (DON'T ASK IF SURE)
ii) age
iii) highest level of education
elementary school
some high school
completed high school
some college/university
college diploma
university degree
graduate or professional degree
iii) Gross farm sales/year
iv) Primary enterprise
cash crops
beef cattle
dairy
hogs
poultry
horticultural
other
v) Secondary enterprise
cash crops
beef cattle
dairy
hogs
poultry
horticultural
other

vi) Considering only <u>on</u>-on-farm sources of income, in what category was your farm's net income <u>before tax</u> last year?

less than $50,000
$50,000 to 74,000
$75,000 to $100,000
over $100,000

APPENDIX III.
Interview guidelines for agribusiness firms and government agencies for the economics of information technology study.

1. Nature of business.
2. What type of up-to-date information is important to you and/or your organization?
3. What activities/business functions are computerized in your organization?
4. Do you use any information services such as DTN, Reuters, Global Link or something similar? Is it real-time or delayed?
5. Do you have any type of internal E-mail system? How about external E-mail?
6. Are you linked to the Internet? If YES, how do you use it? Do you have a Web Site?
7. Do you use cell phones?
8. Do you use videos for training and/or marketing purposes?
9. Do you use any government information services?
10. Have you recently made any changes or are you expecting to make any changes in your information systems in the near future?

APPENDIX IV.
Agrifood organizations and government agencies interviewed.[8]

Agricultural Lending

Vaungh Stewart, Manager-Agricultural Lending
Royal Bank, Toronto

Warren Gear, Manager, Agriculture Canada
Toronto Dominion Bank, Toronto

Paul Stewart, Agriculture
CIBC, Toronto

Scott Laugheed, Agricultural Services
Bank of Nova Scotia, Kitchner

Robert Funk, Agricultural Services
Bank of Nova Scotia, Toronto

Mike McVoy
Farm Credit Corporation, Guelph, Ontario

Agrifood Processing

Ron Usborne, VP Quality Assurance
Caravell Foods, Brampton, Ontario

Peter Conroy, Purchasing
Caravell Foods, Brampton, Ontario

Tom McLaughlin
Lilydale Foods, British Columbia

Scott Richie
Lilydale Foods, Edmonton

Dale McSemec, Director of Marketing
J.M. Scheinders, Kitchner, Ontario

Gary Goetz, Procurement
J.M. Scheinders, Kitchner, Ontario

[8] This is a partial list as some individuals/firms did not want to be indentified by name.

Mac Cole, Information Technology
Better Beef, Guelph, Ontario

George McPhail, MIS Manager
Maple Leaf Pork, Missisauga, Ontario

Jeff Funston, Marketing Manager
Elmira Poultry, Elmira, Ontario

Fletcher's Fine Foods
Red Deer, Alberta

Fletcher's Fine Foods
Vancouver, British Columbia

Darcey Ervin, MIS Manager
Cold Springs Farms, Ltd., Stratford, Ontario

Roley Publicover, Information Systemes and Accounting
Cobi Foods, Wolfville, Nova Scotia

Horticulture Marketing

Brian Mauza, Director of Quality and Product
BC Hot House Foods, Inc., British Columbia

Tom Mueldar, Manager
United Flower Growers' Co-op, British Columbia

Commidity Traders

John Peake, Manager, Commodities
CASCO, London, Ontario

Wes Thompson, CEO
W.G. Thompson & Sons, Ltd., Blienheim, Ontario

Jim Campbell, Sales Manager
Ralston-Purina, Woodstock, Ontario

Steven Tywnstra
Great Northern Bean Co., Alsa Craig, Ontario

Mike Scally
Alberta Wheat Pool, Calgary, Alberta

Bob Rolley
Canadian Wheat Board, Winnipeg, Manitoba

Producer Organizations

Keith Robbins, Information & Communications
Ontario Pork Producers' Marketing Board, Etobicoke, Ontario

Wes Lane, Director of Communications
Dairy Farmers of Ontario, Missisauga, Ontario

Elmer MacDonald, President
Canadian Horticultural Council

Agricultural Inputs

John Meek, General Manager
United Breeders, Guelph, Ontario

Bob McAuley, Marketing
Sandoz Agro Canada, Inc., Mississauga, Ontario

Art Stirling, Marketing
Pioneer Seed, Ontario

Agricultural Equipment

Norm Boyd, VP-Marketing
AGCO Corporation, Atlanta, Georgia

Tony Solon, MIS
AGCO Corporation, Atlanta, Georgia

Paul Hogindorn, CEO
OES, London, Ontario

Doug Self, Manager of Training Programs
John Deere, Mississagua, Ontario

Dorothy White, Communciations
Alfa-Laval, Peterburough, Ontario

George Robinson, Manager, Experiment Station
University of Guelph, Guelph, Ontario

Government Agencies

John Ross, Red Meats Marketing
Agriculture and Agri-food Canada

Ray Bollman, Agricultural Statistics
Statistics Canada

Al de Jong, Ontario Farm Management Accounting Project
Ontario Ministry of Agriculture and Rural Affairs

Ken McEwan, Pork Cost of Production Studies Coordinator
Ridgetown College of Agricultural Technology, Ridgetown, Ontario

Jack Gellner
Agriculture and Agri-food Canada

Alan Grant, Farm Business Management
Nova Scotia Ministry of Agriculture and Agri-Food

Others

Steve Williams
Farm Business Communications, Winnipeg, Manatoba