The Transfer and Adoption of Agricultural Crop Technology: A Case Study of Grain Corn in Manitoba

by

JOSEPH G. THOMSON

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ABSTRACT

An analysis of the transfer and adoption of grain corn technology in Manitoba was undertaken. Grain corn production in the western half of the province's Red River Valley experienced a significant increase between 1970 and 1982. The study assumed an analysis of the adoption of grain corn in the region would provide insights for future agricultural crop technology transfer programs. The study sought to identify the socioeconomic, psychological, and knowledge characteristics of the farmers involved, as well as the economic conditions under which adoption occurred. Data measuring the characteristics of the region's farmers were obtained via a mail survey.

Grain corn was grown in the province before the 1970 to 1982 study period, however total acreage did not reach a notable level until the early 1950's. Farmers who innovated with grain corn prior to 1954 tend to be older than farmers who were eligible to adopt the same technology, but who adopted during a later period or who had not yet adopted by 1983. Adopters of grain corn technology also tend to operate a larger farm business than nonadopters.

Analysis of farmers' use of information indicated the movement of information has been adequate so nonadoption is not the result of an insufficient movement of information. Relatively older and more experienced farmers who were among the first to adopt grain corn tend to rely on public sources of information more frequently than younger, less ex-

perienced farmers who adopted later and who tend to rely on private sources of information more frequently. The observed difference in information use did not account for differences in farmer awareness and knowledge levels. However, the identified difference suggested the public sector was important in diffusing technological information between the innovation and late adoption periods. The use of congruent silage corn technology was also observed to be important in learning grain corn production techniques during the same period. Age, farming experience, and education, particularly a Diploma in Agriculture were found to be important determinants of farmers' use of management practices that are recommended for use in producing all crops, including grain corn.

Farmer attitudes to farm business risk and uncertainty did not account for their adoption action. However, the analysis found that willingness to act under conditions of risk and uncertainty increased with the number of acres of crop and summerfallow acreage a farmer operated. Similarly, farmers who are more willing to act under risk and uncertainty tend to have a greater proportion of their total crop and summerfallow acreage in grain corn, and to grow a greater number of special crops.

The analysis supported previous research that found a technology must be profitable before it is adopted. The model employed to examine the economics of adoption indicated the profitability of grain corn production was a significant factor during the period 1978 to 1982 when grain corn experienced its most dramatic increase in the province and the survey region. The availability of hybrid grain corn seed and the opportunity cost of unsold stocks of grain held on farms were also significant determinants of the rate at which grain corn acreage increased during the same expansionary period.

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Chapter I

INTRODUCTION

Technology is an important component of Canadian agricultural production. The state of technology determines the manner in which agricultural resources are combined, the level of resources used, and the amount of output produced. A change in technology that introduces a method of production requiring less of one or more resources to produce the same output level decreases the cost of production. The freed resources can be reemployed to expand production of the same, or other product(s). Output can also be increased when a change in technology enables output to expand by more than an increase in production factors. Technological advance is therefore seen as a means of improving the incomes of Canadian farmers.

Whether technology does in fact raise farm income depends on its relative effect on production costs and new output levels. When technology is used to reduce production costs, income improves under constant price conditions. However, when technology is also widely used to increase output the resultant shift in aggregate supply can depress prices such that total receipts fall more than the change in costs. Historicaly, this has frequently occurred to many farm products in North America. Farmers have adopted new technologies to improve their competitive position. However by doing so the general level of production has increased and led to lower food prices.

Technology's tendency to increase supply and reduce price is an important determinant of Canadian farm competitiveness in two respects. First, if and when a new technology is not adopted by all farmers at the same time and rate, the competitive position of the initial users is improved relative to subsequent users. More precisely, if and when the number of initial users is such that the adoption of technology reduces their costs of production more than it increases supply and reduces price, the initial users experience an income increase relative to nonusers. The remaining farm population must therefore adopt technology to remain competitive. Second, Canadian agricultural products are sold into international markets, and in order to remain competitive Canadian farmers must apply technology at least as quickly as the farmers of other major food producing nations. In total, new agricultural technology must continually be developed and adopted so Canadian farmers remain competitive in a world of rapid technological change.

Given the importance of technology to agricultural production, this thesis is concerned with the process by which agricultural technology is made available to, and adopted by farmers. In particular, recent advances in biotechnology, which is the use of a biological process to produce goods and services, exhibit the potential to improve agricultural crop production. Therefore this thesis concentrates on the transfer and adoption of crop technology.

1.1 THE TECHNOLOGY TRANSFER PROCESS

According to Fuller (1982) the technology transfer process can be divided into four stages for analytical purposes. Stage 1, the Research Stage, includes the generation of new knowledge achieved through basic research. Stage 2 is the Development Stage, and refers to the interlude where information obtained from basic research is transformed into a technological product. Stage 3 is the Transfer Stage where the technology is introduced to the target population. This stage is characterized by the marketing of the technology, and the development of support systems designed to promote awareness of the new technology. Stage 4, the Diffusion Stage is the period in which farmers decide to adopt the new technology.

The federal and provincial governments, the universities, and private industry are all involved in the development and transfer of agricultural crop technology. While there is a high level of interaction between all agents at each stage of the process, the basic role of each can be delineated. Most of the basic research is conducted at federally sponsored Research Stations and the universities. The Research Stations, universities, and private agents maintain field test sites used to develop technological products. Private marketing agents and the extension services of the universities and provincial governments are responsible for the transfer of technology. Similarly, private marketing agents and extension personnel, as well as farmer organizations are important in diffusing technology.

Just as there is some overlap between the responsibilities of the agents involved, there is overlap between the stages of the transfer process. This is especially true for crop technology because experimental development is conducted at a limited number of locations which do not simulate the full range of agronomic conditions under which the technology may eventually be used. Initial experimental development estimates the practicality of a research idea. If the idea exhibits practical merit, further experimentation to develop the technology into a form that can be used by farmers and to identify any necessary associated agronomic conditions and practices is conducted. For crop technology this typically involves experimentation on test plots. The results from test plots are used to determine whether farmers can use the technology in its test plot form, or whether and what type of additional development is required before farmers can readily apply the technology. Information obtained from experimental farm sites is transfered to potential users so that they can assess the technology. In turn, subsequent users subject the technology to a larger and more variable set of agronomic conditions. The resulting information is used to further assess the technology, and is fed back into the transfer system to increase the information available to even more subsequent users. In summary, the interdependence of the stages of the transfer process results in the accumulation of pertinent information over time.

According to Heady (1957) the amount of information available affects decision making. When the available information is sufficient to reliably estimate the future, decision making is said to involve risk. In other words, when the number of historical observations is sufficient to combine into a probability distribution the probability of any one outcome can be estimated. Such a probability, which assumes the past is repeated in the future, is the risk of the associated outcome occurring in the future. When an insufficient number of historical observations exist to reliably form a probability distribution, decision making is said to involve uncertainty. Uncertainty is also an anticipation of the future, but one that is peculiar to each individual since it cannot be based on a body of historical information.

Because the amount of information available affects decision making, the decision to adopt a new technology involves risk and uncertainty. The number of farmers already using the technology determines the degree of uncertainty the individual faces. The very first farmers to use a new technology are typically part of the development process. They receive limited information from researchers and developers, and consequently face uncertainty. Subsequent users also face uncertainty, but to a lesser degree because they can use the information developed by the initial users. Accordingly, even more subsequent users face even less uncertainty, until at some point the information accumulation is so large the degree of uncertainty involved approaches that of risk. Heady (1957) has also pointed out that very few agricultural climates are so constant that they can be reliably predicted. Consequently, all expectations of future production levels are uncertain, and farming decisions vary by the degree of uncertainty involved.

Technology and information are frequently conceptualized as moving between a series of nodes. According to Slocum (1962) these nodes are equivalent to the actors of the adoption process, namely the innovator, the adopters, and the nonadopters. The first node, or the innovator is the first to use a new technology. The innovator's use of a development increases the amount of information available to the early adopter, who is the next to use a new technology. The late adopter uses a technology after the previous actors have adopted it, and the nonadopter chooses not to use a development. This movement of technology between farmers is referred to as the adoption path.

The adoption path for agricultural technology is also defined in a spatial context related to the transfer process. Innovators can be located in one or more regions. A region is an area that is characterized by similar agroclimatic characteristics such that a technology developed at any one location within the region can be used throughout the region without alteration. Crop technology must be developed to suit each region, therefore when one technology is developed concurrently within two regions, each region contains innovators. When one region preceeds the other the first users in the first region are innovators, while the first users in the second region are early or local adopters. Accordingly, late adopters and nonadopters are found within each adopting region, and are defined relative to the innovators and/or the early adopters of the region.

1.2 SCOPE AND OBJECTIVES

The Canadian farming industry has adopted many technological improvements, especially since the second world war. As mentioned, one of the reasons why new farming technology has been adopted is that technology generally improves productive efficiency by increasing output and/or decreasing costs. This characteristic of modern agricultural technology has also increased the specialization of agricultural production. Farm operators have adopted entire farm systems based on the latest technology to achieve efficiency. Fuller (1982) has suggested that given the increased specialization of production, the transfer process should be examined on an individual commodity basis by using a case study approach.

Grain corn is a good case example of a high technology commodity. Grain corn requires more intensive management than the production of conventional crops. Proceeding chronologically from seeding to harvest time, the following points outline the management necessary for successful grain corn production. Grain corn is grown from hybrid seed, therefore seed must be evaluated and purchased annually. The time of seeding is an important consideration, with the period May 1 to 15 considered optimal. Hamilton (1980) has reported that a loss of approximately one bushel per acre per day in yield can be expected when corn is planted after the first week of May. The early May seeding requirement for corn is in contrast to other cereal grains which can be sewn up to the end of May.

Corn is a poor competitor with weeds and consequently requires a high level of weed management. One of two different management practices can be followed. One is the use of triazine based soil incorporated herbicides. These herbicides provide effective weed control, but they also remain as residues in the soil. This poses a problem when other crops are grown in a rotation with corn. At present field peas and flax are the only crops that are somewhat, but not completely resistant to triazine residues. Triazine resistant canola is also being developed. One solution to this problem is to continuously crop corn. The buildup of disease and insects under a continuous cropping pattern also makes it a somewhat less than satisfactory alternative.

The second method of managing pests in corn is the use of cultural practices. The use of row crop tillage equipment can be combined with the use of nonresidual herbicides to control weed populations. However, the selection of this practice requires approximately $5000, (1984$) investment in addition to the relatively high capital investment the decision to grow grain corn entails. Specifically, corn must be planted with a corn specific planter which can be purchased for $10-25000, (1984$) depending on size. Corn specific harvest equipment which shells the corn as opposed to thrashing it can be purchased for $10-15000, (1984$). As for the harvesting of corn, the Manitoba Corn Committee (1984) recommends the crop be harvested at 27 percent moisture to minimize field losses, cracking, and splitting of the seed. The result of this is most corn growers must dry their crop before storage. This practice presents another cost. Corn growers can have their crop custom dried, or they can purchase a drier and do it themselves. Growers can sometimes offset the cost of a drier by engaging in custom drying.

Since 1970 Manitoba grain corn acreage has increased 20 fold and yield has increased approximately 20 percent. This study examines the adoption of grain corn technology in Manitoba in an attempt to identify factors salient to the future transfer and adoption of crop technology. In so doing, the study examines the current users of grain corn technology, the transfer systems they rely on, and the economic factors affecting the use of the technology. In summary, the objective of this study is threefold:

1. To examine the socioeconomic characteristics of the farmers involved.
2. To examine the role of information and risk and uncertainty in the adoption process.
3. To examine the economic conditions under which adoption occurs.

1.2.1 Grain Corn in Manitoba

As indicated, successful production of grain corn requires the use of hybrid seed. Glenn (1981) has pointed out that the growth of grain corn production on the Prairies has been dependent on the development of improved hybrids. Table 1.1 outlines the changes in Manitoba grain corn acreage that are consistent with the development of hybrid seed technology in the province. Hybrid corn seed technology was developed in the U.S. during the 1930's, and was introduced to Manitoba in the late 1940's. These varieties performed reasonably well, but because they were developed for the warmer, longer growing seasons of the U.S. they did not consistently produce ripe grain. In 1950 the Morden Research Station introduced two hybrids and provincial acreage increased to 30,000 acres only to decrease to an annual average of 5000 acres between 1955 and 1970. In 1971 commercial seed producers began to develop hybrids suited to regions in the province with adequate heat accumulation, and acreage reached 24000 acres in 1977. Table 1.1 indicates that in 1971 fifteen hybrids representing a range of maturity of 2250 to 2600 Corn Heat Units (CHU's) were available. Three of the fifteen varieties were available from the Morden Station. In 1976 nineteen varieties representing the same maturity range were available. Only two of the nineteen were commercially available from public outlets including the Morden Station and the University of Manitoba. In 1977 public outlets discontinued the commercial sale of hybrid seed, choosing instead to release basic seed to commercial growers only. Acreage dramatically increased after 1977 reaching its present annual average of approximately

TABLE 1.1

Growth of Grain Corn Technology and Acreage in Manitoba, 1948-1983

Year	Provincial Acreage[1]	Number of Hybrids Available[2]	Year	Provincial Acreage[1]	Number of Hybrids Available[2]
1948	9900	na	1966	2900	7
1949	22000	na	1967	5500	8
1950	30000	na	1968	2500	na
1951	25000	na	1969	3000	6
1952	19700	na	1970	3500	15
1953	15000	5	1971	9100	15
1954	9900	5	1972	13000	15
1955	6300	na	1973	16000	18
1956	7100	6	1974	5000	19
1957	8000	7	1975	12000	18
1958	7000	7	1976	17000	19
1959	5000	5	1977	24000	14
1960	5500	5	1978	88000	14
1961	4100	6	1979	130000	22
1962	3300	6	1980	140000	21
1963	4500	4	1981	225000	23
1964	5000	4	1982	200000	25
1965	6000	7	1983	190000	26

na: not available

Source [1] 1981 Yearbook, Manitoba Agriculture, AGDEX 850

[2] 2250-2600 CHU maturity range
1948-83 Field Crop Recommendations for Manitoba,
Manitoba Agricultural Services Coordinating Committee,
Manitoba Department of Agriculture

200,000 acres.

In addition to requiring relatively more intensive production management, the marketing of grain corn requires special consideration. Manitoba grain corn is used for industrial processing and livestock feed. Since approximately 1970 producers with high quality corn can sell directly to Calvert of Canada Distilleries in Gimli, Manitoba. The distillery requires approximately 51 thousand tonnes annually. The Mohawk Oil Company located in Minnedosa, Manitoba began purchasing Manitoba grain corn on a regular basis in 1981. Mohawk uses an 80 percent grain corn and 20 percent barley mixture to produce alcohol which they blend with gasoline and retail as "gasohol" fuel for internal combustion engines. Mohawk presently purchases about 14,500 tonnes of corn annually, and expects to increase their usage in the future. Remaining supplies, which averaged 290 thousand tonnes between 1980 and 1982, are used in livestock rations.

As for the actual marketing, a producer may sell corn to another producer who in turn may sell it to the feed market or feed it. A producer might also sell corn to feedmills located in Manitoba or British Columbia. A producer may sell directly to the feedmills, or indirectly to a marketing agent who in turn delivers to the feed market. The primary grain elevator companies will purchase corn in this fashion, as will a variety of smaller grain companies, primarily located in southcentral Manitoba. In 1981 a record grain corn crop resulted in provincial grain corn being delivered to the export market for the first time.

These marketing options, especially the feedgrain trade option, have not always been available to Manitoba corn growers. In fact, as Glenn (1981) has pointed out, dissatisfaction with the Canadian grain marketing system prompted producers to increase their production of special crops including grain corn. Prior to 1973, western Canadian feedgrains had to be marketed through the Canadian Wheat Board, (CWB). This meant feedgrain producers could only deliver grain according to the quotas established by the CWB. When deliver quotas were insufficient western stocks of grain increased and in turn depressed western prices. A farmer in need of cash was therefore obliged to sell coarse grains to the western feedgrain market at depressed prices. In one attempt to overcome this problem, western grain producers turned to special crops. Special crops are crops other than wheat, barley, and oats, and includes the oilseeds, pulse crops, corn, and potatoes. A producer could grow a special crop, deliver to a cash market and receive immediate payment.

Three changes made to Canadian feedgrain marketing policy beginning in 1973 improved the allocative ability of the feedgrain market. One, the Interim Policy of 1973 removed restrictions on the movement of feedgrains within the Prairie Provinces. Two, the Domestic Feedgrain Policy of 1974 (DFP) moved the responsibility for handling and pricing feedgrain from the CWB to the private trade. Three, the DFP also established switching of country for terminal stocks and introduced a storage program in grain deficient areas. With the market better able to right differences in interregional feedgrain supply and demand conditions, subsequent marketing policy changes helped to develop B.C. markets for Manitoba grain corn. At the time feedmills of interior B.C. were importing Albertan barley and oats, and U.S. corn. According to Glenn (1981) the price of Manitoban corn was set according to the U.S. cash price plus exchange, freight, tariff, and appropriate brokerage charges.

Statutory railfreight rates did not apply, while Feed Freight Assistance could be received on grain corn moving by truck as well as rail to interior B.C.. Delivery of grain by truck is preferred in interior B.C. because trucks are better able to access the feedmills scattered throughout the region. Consequently, Manitoba was competitive with U.S. corn in B.C. and markets were developed.

1.3 ORGANIZATION OF THE STUDY

Chapter 2 reviews previous research on technology transfer and adoption to develop an analytical framework, and to identify the factors important to the Manitoban situation. Chapter 3 develops the methods used to gather and analyze data measuring these factors. Chapter 4 presents and interprets the results of analyzing selected primary and secondary data. Chapter 5 summarizes the results and presents suggestions for future research into the transfer of agricultural technology.

Chapter II

REVIEW OF LITERATURE AND DEVELOPMENT OF HYPOTHESES

This chapter incorporates a review of technological change literature with the development of hypotheses of the expected relationships between economic, social and psychological factors and adoption. The chapter uses an interdisciplinary framework to interrelate the derived hypotheses into a systematic relationship of independent variables to the dependent variable of adoption. Within this framework, a model of the adoption process is combined with a discussion of the farm decision making process.

2.1 CONCEPTUAL MODEL

Hobbs et al. (1964) provide the conceptual model for farm technology adoption. Action, A, is a function of an individual's capacity, C, situation, S, and values, V.

(1) $$A = f(C, S, V)$$

The model is based on the premise that human action is goal oriented. Goals are the method by which an individual seeks to satisfy needs. More precisely, the accomplishment of goals is a means of satisfying needs. Actions can be classififed as means or goals, with the classification dependent on the level of generalization. The action of an individual may be directed toward accomplishing a particular goal, but the individual may view the accomplishment of this goal only as an intermediate step in the accomplishment of a more highly valued goal. In this case the intermediate goal is a means of attaining the more valued goal.

2.1.1 Capacity

Capacity, C, is a measure of an individual's perceptual and cognitive ability. Capacity is important in determining an individual's awareness of alternatives and therefore affects the choice of goals, and the means selected to obtain them. Capacity also determines the individual's ability to develop knowledge from experience and information, and therefore influences the level of goal accomplishment obtained.

2.1.2 Situation

While capacity measures whether an individual is aware and capable of completing a goal, situation measures whether the goal of concern is accessible in the technical and social environment. An individual can be expected to strive only for goals that are accessible. Situation measures suitability to the geographic location. Situation also measures accessibility in the social environment, where legal guidelines or institutions must be followed in completing goal oriented action. Situation measures economic incentives and impediments. Under different economic conditions one action may be more suitable than another.

2.1.3 Values

While capacity and situation measures whether the individual can achieve a goal, values, V, measure the individual's desire to achieve it. Values are cultural standards or codes that persist over time and are used by members of the culture to order their intensity of desire for various phenomena. More precisely, individual member's reaction to particular phenomenon are functions of culturally acquired values. Actions are functions of values because although certain values may be identified with a particular culture, a value may be held with varying degrees of intensity by different members of the culture. Consequently, different individuals may have different goal orientations and therefore behave differently. Cultural norms are related to values. Norms delimit acceptable means of satisfying needs. Therefore norms provide a reference point for the selection of goals as well as a criteria for measuring goal accomplishment.

2.1.4 Intereaction of C, S, and V Variables

The interaction of an individual's capacity, C, situation, S, and values, V determines the individual's selection and level of goal accomplishment. There are various levels of goal accomplishment and not just the extremes of success and failure. Two individuals may seek the same goal, but the degree of accomplishment required for satisfaction may differ between the two. This difference is due to different C, S, and V interactions within the individuals. Controlling any two of the three factors while allowing the third to vary can be expected to result in individual differences in the selection of means and goals and consequently in behaviour.

2.2 A MODEL OF ADOPTION

The dependent variable, A, of the conceptual model can be defined as the adoption of a technological development and the model used to examine the variables affecting adoption. Four possible actors in the adoption process have been identified, namely the innovator, the early adopter, the late adopter, and the nonadopter. Individuals differ by the time they decide to adopt, and therefore four states of the dependent variable, A exist at any point in time. The fundamental theorem of this study is that each actor possesses a unique set of C, S, and V characteristics. An examination of these charcteristics will provide insights to the adoption process.

Slocum (1962) describes five stages in the adoption process. In the first stage the individual learns of the existence of a development, but has little knowledge of it. In the second stage, the individual seeks information to consider the development's merits. During stage three, the individual mentally applies the development to the local situation, and uses more information to decide whether to adopt. In stage four the individual actually applies the idea, often on a small scale. Stage five is the stage of acceptance leading to continued use or rejection. This description can be applied to the conceptual model to systematically select an increasing number of C, S, and V factors that differentiate between the actors of the adoption process. The remainder of this chapter identifies these factors within their respective C, S, and V categories while discussing the adoption process.

2.2.1 Capacity

Slocum (1962) identififes awareness as a prerequisite to adoption. An individual must be aware of a development in order to adopt it. The individual's mental capacity determines awareness and the ability to develop knowledge. Knowledge is the link between the stages of adoption. In stage one, knowledge determines awareness. An individual that is aware of a phenomenon is said to have some knowledge of the phenomenon. During stages two and three, the individual accumulates the knowledge required to make the adoption decision. Once adoption is completed, knowledge continues to accumulate as the individual monitors and gains experience with the development. The longer an individual has adopted a development the greater the experience gained and consequently the greater the individual's knowledge. Nonadopters are located somewhere between stages one and three, and therefore can be expected to have less knowledge than adopters who are located between stages four and five. Therefore, one method of differentiating between actors is to examine their relative knowledge levels.

Knowledge can be developed from one or a combination of experience and information. Mental capacity determines the individual's ability to turn information into knowledge. The relatively more mentally capable individual should be able to decode more specialized, and/or technical information, and be better informed, or more knowledgeable as a result. Due to the difficulty in measuring mental capacity, previous studies have used education as one proxy for intellect. For example, Welch (1970) proposed that education's "allocative effect" is important in the decision making process. This effect of education enhances information gathering, processing, and interpreting skills, which in turn improves one's ability to allocate, thereby reducing uncertainty and improving decision making. Therefore, the more mentally capable or educated the individual is, the greater should be the ability to use information to generate knowledge over and above that obtained from experience.

Since it has been hypothesized knowledge varies between adoption stages it follows that this variation may be due to the type of information used. The type of information required to instill awareness in the first stage need not be as detailed as that required in subsequent stages. In stages two and three more specific information is required in order to apply the development to the individual's case. In stages four and five information of a less basic variety is needed for continued evaluation. This pattern of information use has been observed by previous research. Wilkening (1956) and Marsh and Coleman (1955) found that earlier adopters tend to use more specialized, and a greater number of information sources. This observation also follows from a consideration of the technology transfer process which also consists of a series of stages. In stage two, a technology is researched and developed, is transformed into a marketable product in stage three, and is adopted in stage four. The first adopters are, by definition, the first users to gain experience with a development. Therefore, the amount of information on the development's practical application is limited, and first users must avail themselves of information from sources located earlier on in the transfer process. These sources include researchers and developers, and as such represent specialized sources concerned with technical information.

2.2.2 Situation

In stage two and three of Slocum's (1962) adoption process the individual seeks information to consider the merits of a technology as it applies to the situation. In order to be adopted an agricultural crop technology must be suited to a variety of social and economic constraints. For example, it must be possible to obtain technological inputs and sell the resultant production. Agronomic conditions such as climate, soil, and fertility determine where and how successfully a crop technology can be used in production. Agronomic and economic conditions also determine the profitability of using the technology.

The literature agrees all technological developments must exhibit the potential to increase profit in order to be adopted. In a seminal article, Griliches (1957) found the increased profit expected from the use of higher yielding hybrid corn seed was the most important factor in explaining the increased use of hybrid corn. Dixon (1980) examined the growth of hybrid corn 20 years after Griliches, at a point in time when hybrids had completely replaced open pollinated varieties. Dixon supported Griliches' finding that expected profitability was an important factor in determining the rate of adoption of hybrid seed.

After an individual examines and decides a suitable technology is profitable adoption is determined by the size of the investment required to use the technology and the individual's financial status. The smaller the investment, measured as a proportion of the individual's net worth, required to use a technology the more likely it is to be adopted. The individual must be able to obtain sufficient capital before adoption can be considered. Such capital is typically obtained from one, or a combination of two sources. In the event the individual has total equity in the farming operation any liquid capital in the form of retained earnings can be used. Alternatively, should the individual not have sufficient retained earnings, equity can be used as collateral to borrow capital. In this case the individual must have sufficient initial equity for credit institutions to be willing to lend money.

The following decision model can be used to conceptualize the situational factors an individual might consider during stages two and three of the adoption process. Since this study is concerned with the adoption of crop technology, the model is applied to the decision to adopt a new crop. The profitability of a new crop can be estimated by the product of expected price and yield less the expected cost of production. As Griliches (1957) and Dixon (1980) observed, the use of a new technology must not only be seen to be profitable, but more profitable than production from existing technology. Therefore in addition to variable and capital costs of new technology use, the model includes an opportunity cost variable. This variable is included to capture the opportunity cost of production that may not occur as a result of adoption. For example, if a new crop is adopted and produced in replacement of a previous crop, the expected profitability of the new crop must be greater than that of the existing crop. The profitability of the existing crop is the opportunity cost of not producing it.

(2) E(PROFITABILITY) = E(PRICE X YIELD) - E(VARIABLE + FIXED + OPPORTUNITY) COSTS

The crop decision model uses expected price and cost estimates. The parameters are preceeded by E to reflect the uncertainty of technological change. There are several relevant dimensions of uncertainty involved. One includes yield uncertainty. Yield is a function of weather which is one of the largest determinants of the variability of crop production. The weather conditions that prevailed during the research and development stage may not be replicated in subsequent years. Similarly, crop research and development is conducted at a limited number of agroclimatic locations, and a potential adopter's location may differ from the research and development location. Therefore the potential adopter is also uncertain of the effect different cultural practices will have on yield.

The uncertainty surrounding a new crop's yield compounds the uncertainty of farm decision making. Many agricultural crops are produced in an economic environment approaching pure competition. Price is determined by economic activity beyond the control of the farm decision maker. Furthermore, the economic conditions determining crop prices are not predictable. Therefore, information sufficient to estimate the variability of price may not exist, and the decision maker must deal with price in addition to yield uncertainty.

Modern agricultural production is largely dependent on the use of petroleum. Petrochemical inputs including fuel, fertilizer, and pesticides constitute a large portion of the variable costs of production. The price of petroleum is influenced by global economic activity similar to that influencing world crop prices. However, crop production costs have not historically been as variable as product prices. Rather, and especially since the early 1970's crop production costs have risen annually.

The importance of yield and price uncertainty must be considered relative to the aggregated costs of the crop decision model. When the decision to adopt a new crop technology requires investment in fixed components such as machinery and equipment, the impact of risk and uncertainty is especially significant. This impact is best summarized in terms of increasing uncertainty. The magnitude of fixed investment can be estimated with reasonable certainty so that there is little risk of purchase price variability involved. Such investment is made to produce a crop for which there is a large probability that the variable cost of petrochemical inputs will increase. These two relatively certain expenses must be incurred in order to produce a crop where the yield and price are not certain. Should the decision maker choose to adopt a new crop in partial or complete replacement of an old crop, risk and uncertainty is compounded further still. Specifically, the price for, and the costs of producing the old crop are subject to the vagaries of the same marketplace, and therefore entail uncertainty and risk similar to that of the new crop. However, if the decision maker has grown the old crop for a considerable period of time, yield uncertainty is not as great as that of the new crop. In other words, a greater number of observations with which to estimate the probability of old crop yield variation is available. In summary, investment in new crop technology can be figuratively conceptualized as the cost of the opportunity to incur increased uncertainty. This conceptualization highlights the importance of profitability in bringing about adoption. The increase in expected profitability must be substantial in order to incur the increased uncertainty of adoption.

2.2.3 Values

Given the decision to adopt a new technology is fraught with uncertainty, whether adoption occurs partially depends on the individual's attitude to act under conditions of risk and uncertainty. One would expect the adopter to be characterized by a value orientation or attitude that includes a willingness to take chances. For example, Ramsey (1959), Hoffer and Stangland (1958), and Strauss (1959) have all found a risk averse orientation to be negatively associated with the adoption of recommended practices. Similarly, Dillon and Heady (1960) as cited by Hobbs et al. (1964) have shown managers may discount long run returns heavily, and subsequently make decisions which minimize losses rather than maximize returns. In the case of the decision to adopt new technology, a decision maker may discount the long run profitability of a development because of the uncertainty of its performance, and/or the amount of capital investment required in the short run.

An individual's attitude to act under risk and uncertainty is dependent on the degree of uncertainty involved. An individual's position on the adoption path is related to the amount of information available and therefore also affects the degree of uncertainty involved. More precisely, by definition the innovator decides to adopt at a time when the performance of a development is not well documented. The uncertainty and related risks the innovator faces are greater than those faced by subsequent adopters. Documentation increases, and uncertainty decreases as the development is adopted by subsequent actors. Therefore, one would expect willingness to adopt to increase as the risk and uncertainty conditions decrease.

Assuming an individual has sufficient equity to invest in new technology, whether equity is used depends on the individual's attitude to doing so. The individual who places a high value on security may choose not to use debt capital since such action can result in a loss of equity should the investment fail. A high equity position is considered a secure position since fewer credit repayment obligations are necessary in the event of an economic downturn. Furthermore, equity can be used to sustain the business should the downturn be a prolonged one.

Although all or part of the equity put forward can be lost, the decision not to use borrowed capital is made somewhat at the expense of foregone income. If the aftertax rate of return earned on the use of a business's total assets, including borrowed funds is greater than the aftertax rate of interest that must be paid for the use of borrowed funds, the return on owner's equity is greater than it would have been had no money been borrowed. This suggests that individuals who are willing to use debt capital are not only relatively less averse to risk, but are also relatively more profit motivated. The combination of these two value orientations within an individual can be expected to be reflected in business behavior.

The norms of a culture can also play an important role in the decision to adopt a new technology. The principal function of cultural norms is to delimit acceptable means and goals. In other words, norms provide a reference point for the selection of means and goals. The means chosen and the goals sought by a traditional individual are comparable to those of the immediate environment, (Hobbs et al. (1964)). In the case of the adoption of farm technology, if a technology is not used by the traditional farmer's reference group, it is unlikely that many farmers would adopt the technology. Traditionalism is a prominent characteristic of many rural cultures, (Slocum (1962)). Therefore adoption can be expected to be positively related to an untraditional attitude.

2.2.4 Interaction of Capacity, Situation, and Values

Slocum (1962) reports research that found younger farm operators are more likely to be aware of and willing to accept new ideas, but are not always in a position to adopt them because of a lack of capital, or independence in decision making. Strauss (1959) also reported finding a negative relationship between age and economic aspiration. These findings suggest adoption and the interaction of the independent variables of the conceptual model should be considered within a time context. First, capacity or the individual's native ability to recognize technological opportunities can be expected to be relatively constant over the lifetime of the individual, perhaps declining in later years. Knowledge, which is an indicator of capacity, can be expected to increase with age and experience. Second, and following Slocum's (1962) outline, younger farmers can be expected to be willing to adopt new farm technology, but may lack the necessary resources. As the individual grows older and more experienced, resources in the form of business equity can be expected to increase until they are sufficient to invest in new technology. However, while the individual grows older, attitude and willingness to change and/or adopt new ideas may decrease as the desire for security increases. In total, since capacity, situation, and value variables have been observed to change with the age of the individual, age is hypothetically related to adoption of technology. Specifically, the individual must be sufficiently old to have accumulated the necessary knowledge and resources, but not so old as to be unwilling to change and/or risk security.

2.2.5 Congruence

Brander and Strauss (1959) found that technological developments are more likely to be accepted if they can be related to an existing cultural pattern. This finding needs to be considered with respect to the adoption influencing factors previously discussed. When a new technology is similar to existing technology, the degree of uncertainty surrounding the new development is less. Observations on the performance of the old method can be used to estimate the performance of the new development. Similarly, should the cultural practices recommended for use with the new technology be comparable to those of the existing technology, potential adopters will not need to expend as much time and energy learning and testing associated techniques. Furthermore, should the capital equipment used with the existing technology also be appropriate for use with the new technology less investment is required to adopt the new technology. This reduces the financial risk of adoption.

2.3 SUMMARY

This chapter applied a description of the technology adoption process to a human action model to systematically develop the following hypothesis of the factors affecting the decision to adopt. An individual must be aware and develop knowledge of a technology in order to adopt it. The individual's mental capacity, measured by education, affects the generation of knowledge by affecting the individual's ability to use information in augmenting experience. With knowledge the individual is able to determine the suitability of a technology. A technology is adopted only when it is suitable. The individual must have sufficient capital to invest in a technology. Suitable technology is normally invested in only when its use is seen to be profitable.

Since the adoption of farm technology typically involves risk and uncertainty, the individual's value system determines the individual's desire to adopt a suitable technology. The adopter must be willing to act under uncertain conditions, and risk security. An individual must also be willing to use retained earnings and/or borrowed funds to adopt should a technology require capital investment. Adoption of technology involves change and is negatively influenced by a traditional value system. Willingness to try new ideas and use retained earnings and/or debt capital changes with the age of the individual. The individual must be sufficiently old to have accumulated the necessary resources, but not so old as to be unwilling to change and/or risk security. When a new technology is similar , or related to the use of existing technology, the individual may be better prepared and more willing to adopt. Knowledge of congruent technology is more readily developed, and the required capital investment may be less.

Chapter III

METHODOLOGY

This chapter discusses the methods used to meet the objectives of the study. It contains four major sections. The first section describes the general approach taken in developing the analytical models of the study. The second section describes the interdisciplinary model employed to analyze the data described in the third section. The fourth section describes the model used to analyze the economics of adoption.

3.1 OVERVIEW

Chapter 2 conceptualized the adoption of an agricultural crop technology as a temporal process involving related changes in the technical development and farmers' assessment of a technology. In turn, the interaction of a farmer's mental capacity, situation, and value system over time was hypothesized to determine if, as well as when the individual adopts a technology. This chapter describes two models used to test this conceptualization. The models examine each of the many hypothetical variables of adoption one at a time. The first, or interdisciplinary model is used to identify farmers' mental capacity, situation, and value system characteristics that account for their adoption action. The second, or economic model includes situation factors only, and is used to examine the economic conditions under which grain corn production technology was adopted. Economic conditions are hypothetically one dimension of an individual's situation that interact with other situation, as well as mental capacity and value system variables. To this extent the economic model is a component of the interdisciplinary model.

Although the conditions examined by the economic model are related to the other components of adoption examined by the interdisciplinary model, the two models were not estimated simultaneously because the data analyzed by each model differs. Quantitative estimates of the variables of the interdisciplinary model were obtained by a survey of Manitoban farmers conducted from November 1983 to January 1984. The survey data includes observations on farmers who first grew grain corn anywhere between the years 1937 to 1982, while the economic model was estimated from secondary data measuring economic incentives as they existed in each of four survey subregions between 1970 and 1982. Data measuring economic conditions prior to 1970 was not consistently available. Furthermore, as outlined by Table 1.1, 1970 to 1982 was the most notable period in the adoption of grain corn in Manitoba. Also, unlike the survey data the secondary economic data measures general conditions for each subregion, and does not necessarily measure conditions as they existed on each survey respondent's farm.

Preliminary analysis of the data indicated the respondents have been farming for anywhere from 1 to 50 years, and that the grain corn growers of the sample had adopted grain corn technology anywhere from 1 to 46 years prior to 1983. Since the sample includes observations on the characteristics of farmers as they existed in 1983, the static data do not necessarily measure farmers' characteristics as they existed if, and when the decision to, or not to adopt grain corn technology was made.

Since the purpose of the interdisciplinary model is to identify farmers' characteristics that account for their adoption action, the model's design facilitates interpretation of the analytical results in terms of intertemporal change. To assist in this interpretation the model tests for a relationship between each characteristic and a simulated time component. The identification of a significant temporal pattern is used to determine how farmers may have changed as adoption progressed. The results of examining intertemporal change with the interdisciplinary model are related to the results of examining change with the economic model.

3.2 THE INTERDISCIPLINARY MODEL

This section develops the following specification of the interdisciplinary model. The model outlines farmers' socioeconomic, psychological, and use of information characteristics and their hypothetical relationship to adoption. Farmer characteristics are measured by the independent variables of equations 3.1, 3.1.1, 3.1.2 and 3.1.3. Equation 3.1.1 is a definitional statement included to indicate knowledge is measured with three separate variables. Equation 3.1.2 outlines the factors hypothetically interrelated in the development of knowledge, and equation 3.1.3 includes factors that are hypothetically related to adoption through the interaction with risk and uncertainty.

3.1 $\mathrm{ADOPTIONi}_t = f(\mathrm{LOCi}_t\ ,\ \mathrm{KNOWLEDGEi}_t\ ,\ \mathrm{RISKi}_t\ ,\ \mathrm{CONGi}_t)$

3.1.1 $\mathrm{KNOWLEDGEi}_t = g(\mathrm{AWAREi}_t\ ,\ \mathrm{RECOPRACi}_t\ ,\ \mathrm{CORNKNOWi}_t)$

3.1.2 $\mathrm{KNOWLEDGEi}_t = h(\mathrm{PRIVINFOi}_t\ ,\ \mathrm{PUBINFOi}_t\ ,\ \mathrm{PEINFOi}_t\ ,\ \mathrm{EDUCi}_t)$

3.1.3 $\mathrm{RISKi}_t = j(\mathrm{AGEi}_t\ ,\ \mathrm{SIZEi}_t\ ,\ \mathrm{CREDITi}_t\ ,\ \mathrm{PINSi}_t\ ,\ \mathrm{INSTYPEi}_t\ ,$

$SPECROP^{i}_{t}$, $GCORN^{i}_{t}$)

where i = farmertype; innovator, early adopter, late adopter, nonadopter.

t = adoption period; before 1954, 1954 to 1969, 1970 to 1982.

LOC = geographic location of farm; subregion 1, 2, 3, or 4 of survey region.

KNOWLEDGE = knowledge is measured by 3 individual factors.

RISK = attitude to risk and uncertainty; ranges by 1 from 1 to 3.

CONG = congruence or whether the farmer adopted silage before grain corn; 0, 1.

AWARE = index of awareness of grain corn technology; ranges by 1 from 1 to 3.

RECOPRAC = index of use and knowledge of recommended crop management practices; ranges by 1 from 1 to 3.

CORNKNOW = index of corn growers knowledge of recommended grain corn growing practices; ranges by 1 from 1 to 3.

PRIVINFO = frequency of use of private sources of information; =1 if used more frequently than public or personal sources.

PUBINFO = frequency of use of public sources of information; =1 if used more frequently than private and personal sources.

PEINFO = frequency of use of personal sources of information; =1 if used more frequently than private and personal sources.

EDUC = highest level of education attained; elementary, high school, diploma in agriculture, one or more university degrees.

AGE = age of the operator; includes eight ranges.

SIZE = acres under crop and summerfallow in 1983; includes six ranges

CREDIT = proportion of total estimated farm capital owed to a credit agency; 0-15, 16-30, 31-50, 50-75 % or more

PINS = proportion of total grain and oilseed acreage normally insured; 0, 1-25, 26-50, 51-75, 75 % or more

INSTYPE = type of crop insurance used; includes four types.

SPECROP = number of special crops grown in 1983; 0, 1, 2 or more.

GCORN = proportion of total cultivatable acres sown to grain corn in 1983; 1-25, 26-50, 51 % or more.

3.2.1 Dynamics of the Model

Chapter 2 hypothesized that adopters of a technology at any specific point in time possess characteristics that differentiate them from nonadopters, and that the characteristics required for adoption change over time as the technical quality of the respective technology increases. The model tests this hypothesis by dividing the survey sample into three subsamples consistent with the development of grain corn technology in Manitoba, and statistically testing whether farmers' characteristics differ in any one, or between each subsample. Table 1.1 described how prior to 1950 the principal grain corn seed available in Manitoba included that imported from the U.S.. Acreage peaked in 1950 and began to decrease thereafter despite the fact the Morden Research Station began to develop better suited hybrids. After 1970 increased commercial production of hybrids increased the variety and quantity of seed available, and acreage again began to increase reaching today's present level. The model assigned the sample of grain corn adopters to one of three subsamples or groups according to whether the respondent adopted prior to 1954, between 1954 and 1970, or after 1970.

The dependent variable ADOPTION in equation 3.1 of the interdisciplinary model represents the measure used to estimate the stage of development of the first hybrid(s) used by each grain corn adopter in the survey sample. The variable was used to assign each adopter to one of three groups. Specifically, the survey asked farmers to indicate the year they first grew grain corn. Respondents who indicated adopting grain corn prior to 1954 were assumed to have experimented with U.S. and the first Manitoba hybrids, and were assigned to the first group. Respondents who first grew grain corn between 1954 and 1969 were assumed to have adopted subsequent Morden hybrids, and were assigned to the second group. All adopters in groups 1 and 2 are referred to as innovators. Respondents who first grew grain corn after 1971, when commercial production of hybrid seed began to increase were assigned to the third group. Since grain corn production expanded most notably after 1977, respondents who adopted between 1970 and 1977 are referred to as early adopters, while those who adopted after 1977 are referred to as late adopters.

The survey also asked respondents to indicate the number of years they had been engaged in full time farming. This information was used to assign the nonadopters of the sample, as well as reassign some of the late and early adopters to the appropriate group. Group 1 contains innovators who adopted before 1954 and therefore who must have been farming for 30 or more years in 1983. Nonadopters with 30 or more years farming experience were assumed eligible to adopt the hybrid technology the innovators did and were assigned to group 1. Nonadopters in group 1 include late and early adopters, and those who had not adopted by 1983. Similarly, group 2 contains farmers who adopted in, or after 1954 but before 1970, and therefore who must have been farming for a minimum of 14 years in 1983. Nonadopters, including late and early adopters and nongrain corn growers, with 14 to 29 years full time farming experience were assumed eligible to adopt the respective grain corn technology and were assigned to group 2. Group 3 contains noncorn growers, and early and late adopters with 13 or fewer years farming experience. In summary, the adopters of groups 1 and 2 are the innovators, and the nonadopters include early and late adopters and noncorn growers, while the adopters of group 3 include late and early adopters and the nonadopters include noncorn growers. Each group contains observations on the characteristics of adopters, subsequent adopters, and nonadopters. Comparison of the farmertypes within and among the three groups enables testing of the hypotheses that adopters' characteristics differ from nonadopters, and that said characteristics change over time.

3.2.2 Knowledge

Three indices designed to capture the association of different states of knowledge with different stages of the adoption process are included. AWARE is designed to discern whether nonadopters are aware of grain corn technology, knowledge relevant to stages one and two before adoption occurs. RECOPRAC is intended to measure knowledge associated with the use of, while CORNKNOW is designed to measure knowledge resulting from adoption of grain corn technology. The composition of the three indices is presented in Table 3.1.

The awareness index, AWARE, is equal to the sum of the weights assigned to the answers to five general questions on grain corn production. The five items included the most obvious differences between grain corn and grain production practices. Therefore it was possible to identify one correct response which was assigned a weight of 1, while all other responses were assigned a weight of 0.

TABLE 3.1

Composition of Knowledge Indices

Knowledge Index and Item	Survey Question Number	Weights 1	.75	.5	.25	0
AWARE						
Seeding date	15	before May 15				after May 15
Seeding date	16	before May 30				after May 30
Seeding Rate	8	20-24000 ppa				<20 or>24000 ppa
Herbicide	18	Eradicane				all others
Harvest Moisture	24	25-29%				<25 or >29%
RECOPRAC						
Plant tissue test	23	1-4 yrs.				never
Soil test	17	every year	2 yrs.	3 yrs.	4 yrs.	never
Sprayer Calibration	22	reply #2		3*	4**	#1,5
Trash Management						
Burn Straw	26	NO				YES
Straw Chopper	27	YES				NO
CORNKNOW						
AWARE-Seeding Rate						
No. of hybrids	7	>=4		3*	2**	1
Crtd. Seeding Rate	8-10	correct				incorrect
Seed Depth	11	1-3				>3
Drying Temp.						
Feed	25A	190 F				><190 F
Distillery 2	25B	140 F				><140 F

* weight=.67 ** weight=.33

The second knowledge index, RECOPRAC was designed to measure an individual's use of five recommended crop management practices. Successful grain corn production requires relatively more intensive management than the production of traditional cereal crops, and an individual's use of such practices indicates knowledge of this fact. The five items included in the index are relatively new developments recommended to improve the efficacy of crop production inputs. These practices are especially recommended for use in producing monocultural crops. Like the AWARE index, two of the five items included in the RECOPRAC index had an obvious right or wrong, YES-NO response weighted 1-0 as per Table 3.1. The three remaining items do not have an obviously correct response. One item is the frequency of plant tissue testing. Provincial government extension personnel and private fertilizer retailers recommend tissue tests be conducted annually. However, a more economical use is frequently made in actual practice. Plant tissue testing is used to analyze a crop's nutrient compositon and to trace for disease and pesticide residue. The test need only be conducted when disease or herbicide damage is suspected, or when crop and fertilizer rotations are changed. Consequently, if the survey indicated tissue testing was conducted at least once every four years a weight of 1 was assigned to the item and a 0 otherwise. Similarly, soil testing need not be conducted annually if the producer closely monitors and compares fertilization levels with crop yield. If the survey respondent indicated annual testing a weight of 1 was assigned to the item. If the respondent indicated testing every other year a weight of .75 was assigned, and so on decreasing by .25 to every four years, with a weight of 0 for a response of never testing. The Manitoba Agricultural Services Co-ordinating Committee (1983) recommends calibrating field sprayers annually to ensure accuracy of application rates and to reduce the threat of crop and environmental damage. There are various ways of calibrating but the most accurate method is a time consuming chore which involves measuring the water dispensed from the sprayer as it travels over a premeasured distance at a constant speed and sprayer pressure. Few farmers calibrate annually, if at all. Moreover, modern sprayers are sufficiently accurate that less precise calibration methods can occassionally be used. Replies 2, 3, and 4 to survey question 22 includes all appropriate methods and were weighted 1, while reply 1 was weighted 0 in the RECOPRAC variable. Only 1 respondent gave reply 5, therefore the observation was dropped from the sample.

The third knowledge index, CORNKNOW is intended to differentiate between corn growers' knowledge of grain corn production techniques. CORNKNOW is composed of four items of the AWARE index, and the four additional items included in the first version of the survey form. A more detailed survey form, (included in Appendix A) asking four more questions on respondents' use of grain corn growing practices was sent to known corn growers. Two of the additional items were used to correct the fifth or remaining AWARE item, i.e. seeding rate, Table 3.1. Specifically, the information given in questions 9 and 10 can be fit into a formula of the dimensions of a corn seeder to determine whether the seeding rate response given was accurate. If it was accurate a weight of 1 was assigned to the item, and a 0 otherwise. The third additional survey item included the number of hybrid corn seed varieties used. The Manitoba Corn Committee, MCC (1983) recommends using three to four hybrids annually since no one hybrid has been found to excel under all agronomic conditions. Accordingly a weight of 1 was assigned to a response of four or more hybrids, a .75 weight to three hybrids, .25 to two hybrids, and a 0 to only one hybrid. The MCC (1983) recommends seeding corn to a depth of 2 inches, however in actual practice moisture conditions and soil type may require a variation of the recommendation. Consequently a weight of 1 was assigned to a response of 1 to 3 inches to question 11, and a 0 otherwise. CORNKNOW includes one more item on grain corn drying practices. This item was included in both versions of the survey form, but involves knowledge resulting from adoption. The

MCC (1983) recommends corn for animal feed and distillation be dried at different and specific temperatures. A weight of 1 was assigned to the correct temperature, and a 0 to the incorrect.

3.2.3 Information

Knowledge accumulation is a complex process affected by a variety of factors. Information and education are two of the more important factors and are included in equation 3.1.2 to outline their interaction with knowledge. The individual uses information to obtain knowledge. Information and education intereact to form ideas. In the case at hand, idea refers to the idea to consider growing grain corn, and knowledge refers to the concrete, technical information required to apply the idea. In other words, equation 3.1.2 does not outline the sources of information farmers use to obtain new technological ideas, but is designed to measure what sources farmers consult to obtain the technical information required to apply an idea they already have.

Since information can be obtained from one or a combination of sources, it is difficult to reliably estimate where an individual obtains the necessary information to render an adoption decision. Should an individual tend to use one or a particular type of information source the tendency should be revealed in repeated sampling. This premise was followed in designing the survey questions on information. The survey posed three questions on the use of information in making decisions concerning the use of three production inputs, namely fertilizer, herbicide, and seed. Fertilizer, herbicide, and seed are integrally connected in the crop production decision. The decision to grow a crop involves, at the very minimum, some consideration for potential weed problems and methods of control. Furthermore, these three inputs can normally be obtained from one outlet. Each of the three survey questions was followed by a similar list of seven sources of information. For each question respondents were asked to rank the three sources they considered the most important in helping them make the respective decision. Since the decisions are related, should the individual rely on any particular combination of information sources, this tendency should reveal itself in the individual's response to each question.

The list following each use of information question includes private, public, and personal sources of information. Other farmers and experience were included within the personal sources of information category, while sources of both technical and general forms of information were included in the public and private source categories. These categories were used to construct the information variables of equation 3.1.2. PRIVINFO is equal to 1 if the survey respondent indicated using more private than public and personal sources of information. PUBINFO and PEINFO are similarly defined. This categorization was used because according to Fuller (1982) the roles of the various transfer agents are less well defined than they once were. The categorization is used to determine the importance of other farmers in the transfer process, and whether the private or public sector is the most frequently used source of information.

3.2.4 Education

Education, EDUC, is a proxy for mental capacity. The survey respondent was asked to indicate the highest level of education obtained, and was given a choice that ranged from elementary school through to a graduate degree. The question made a distinction between agriculture and nonagriculture university degrees. However, only eight respondents of the total sample of 173 indicated they had a nonagriculture Bachelor or graduate degree. Therefore, the difference between an agriculture and nonagriculture education was not included in the index. The categories of the index include elementary school, high school, Diploma in agriculture, and one or more university degrees.

3.2.5 Attitude to Risk and Uncertainty

Given that the overall performance of a new technology cannot be known with certainty, adopters were hypothesized to be more willing to act under conditions of risk and uncertainty. The variable RISK was specified to quantify farmer attitudes to risk and uncertainty. When the items of such an index covary in a consistent fashion, the index is said to be measuring a single, common attitudinal dimension. The method of principal components is one method of examining interitem covariation. Piazza (1982) used the method of principal components to develop an index measuring racial attitudes in America. Piazza (1982) posed five questions related to black American economic prosperity to survey respondents. The question had from two to four possible replies which were weighted by assigning a 0 to the least positive reply, a 1 to the next, and so on to the most positive reply. This weighting was used to estimate the correlation between each question, or item. Of the items that were significantly correlated, Piazza (1982) chose only the subset that had first factor loadings greater than .5. Piazza (1982) then examined the roots of the first factor loadings to determine how many attitudinal dimensions were being measured. With 1's in the diagonal of the correlation matrix the principal component solution yielded only one eigenvalue, (Protter and Morrey (1964)) greater than 1. Consequently Piazza (1982) concluded that the index was measuring one dimension, and therefore used it in subsequent analysis.

The method described by Piazza (1982) was followed in developing an index, (RISK) designed to measure attitude to risk in a farming sense. The survey posed seven questions designed to measure different dimensions of this attitude. Respondents were asked to reply to each of the seven items by selecting one out of four to six possible answers that coverred the continuum from agreement to disagreement. Responses were weighted with the largest weight assigned to the least risk averse answer. Whole number weights varying by 1 and ranging from 1 to the maximum number of responses were used.

The following is a discussion of the rational for each of the seven attitude items of the survey. Question numbers refer to the survey included in Appendix A. The first item, question 32 measures the respondent's willingness to buy land. The response of outright purchase was considered the most willing and was assigned a weight of 5, while a response of not to buy was deemed the least willing and was assigned a 1. Question 33 is designed to measure the individual's willingness to use owner equity to purchase more land. The response of willing to mortgage as much as necessary was assigned the largest weight of 6, while the response not to mortgage was given a 1. Question 34 solicits the individual's willingness to try new farming ideas and practices. A response of like was assigned a 4, while unlike was assigned a 1. Question 35 attempts to address the notion that profit motivated individuals are risk takers. A response of like was deemed to indicate the respondent was such an individual, while a response of unlike indicates an unwillingness to take the chance described in the question but does not imply a lack of profit motivation. Question 36 examines the individual's willingness to use owner's equity to borrow intermediate capital. Question 36 is one degree less than question 33. More precisely, a risk averse individual might be willing to mortgage for a period of time shorter than the period required to pay back investment in land. A like response to question 36 was assigned a 4, while unlike was assigned a 1. Question 37 is similarly one degree less than question 36. An individual might be willing to use an operating loan that can typically be paid back within one year, but unwilling to borrow for a longer period of time. A response of like to question 37 was weighted 4, and unlike was weighted 1. Question 38 is an attempt at measuring the individual's willingness to gamble. The odds are given, with a 50 percent chance the individual can expect a $5 = .5 x $10 return. Therefore, a like response indicated the individual was more of a gambler than the indiviudal who replied unlike, and weights were assigned accordingly.

The Spearman correlation between each question was estimated and is reported in Table 3.2. Questions 32 and 35, 35 and 37, and 36 and 37 are significantly correlated. Of these four items, only questions 35, 36, and 37 have significant first factor loadings. The second factor loadings for items 35, 36, and 37 are significantly smaller than for the remaining items, indicating the first principal component successfully accounts for the variation in items 35, 36, and 37. A principal component solution of the matrix of items 35, 36, and 37 resulted in only one significant eigenvalue of 1.65. Therefore, question 35, 36, and 37 are

TABLE 3.2

Interitem Correlation and Principal Component Factor Loadings of Attitude to Risk and Uncertainty Items

Survey Question Number	Attitude Dimension	32	33	34	35	36	37	Factor Loadings 1st	2nd
32	purchase land							.38	.61
33	long term mortgage	.174						.42	.52
34	try new ideas	.077	.009					.47	-.29
35	profits & risk	.380*	.182	.179				.65	-.01
36	med. term mortgage	.196	.252	.137	.188			.66	.07
37	sht. term mortgage	.195	.164	.130	.305*	.492*		.73	-.06
38	gamble	-.108	.010	.141	.145	.115	.179	.41	-.64

* significant at the 95% level

measuring one common dimension of attitude to risk and uncertainty.

3.2.6 Age

Age was hypothesized to be related to adoption through the interaction with farming experience and attitude to risk and uncertainty. Younger farmers were hypothesized to be more aware of and willing to try new ideas, and therefore more likely to adopt new technology. Since age determines the maximum number of years of farming experience an individual can have, age was hypothesized to be positively related to the accumulation of knowledge and business equity. Consequently, although adopters were hypothesized to be relatively younger, they cannot be so young as to not have accumulated the resources required for adoption. In total, adopters were hypothesized to be younger than nonadopters, and age was hypothesized to be a factor in determining the resources available to a farmers, as well as farmers' willingness to act under conditions of risk and uncertainty.

The variable AGE measures the age distribution of the four farmer-types, and enables estimation of the sample's representativeness of the population and testing of the hypothesis that farmertypes differ by age. The age categories are those employed by the Census of Agriculture (1981), and are presented in Table 3.3. Given that the design of the model splits the data sample into three subsets of farmers with increasing amounts of farming experience, each subset does not contain farmer-types in each age category. Therefore, the categories were adjusted for each subset. The rationale for this adjustment is presented in the discussion of the method used to estimate the model.

3.2.7 Farm Resources

The size of the individual's farm is one of two variables used to measure farm resources, or the availability of capital. The number and fertility of acres affect the capital value of a farm and therefore the total amount of capital potentially available. The amount of capital actually available is determined by the individual's equity in the farm business. Given the use of borrowed capital involves risk and adopters were hypothesized to be less risk averse, adopters were expected to use more borrowed capital than nonadopters. Borrowed capital can be used to invest in technology and land, therefore adopters were also hypothesized to farm larger farms than nonadopters.

The variable measuring farm size, SIZE is equal to the cultivatable land area of the survey respondent's farm. The area categorizations used reflect the Canadian land classification system's impact on farm size. The variable measuring use of borrowed capital, CREDIT is the proportion of the survey respondent's estimate of the total value of all farm land, buildings, machinery, and livestock owed to a credit agency(s). The categories employed are those included in the survey. The categorization used in the SIZE and CREDIT variables is also given in Table 3.3. As for the age variable, the categories of the size and credit variables were adjusted for each adoption sample to conform with

TABLE 3.3

Categories of Farmer Age, Farm Size, Use of Credit, and Crop Insurance Variable Indices

	AGE	SIZE	CREDIT	PINS
Category	Age (yrs.)	Farm Area (acres)	Credit (% owed)	Proportion Crop Insured (%)
1	15-24	1-320	0-15	0
2	25-29	321-640	15-30	1-25
3	30-34	641-960	30-50	26-50
4	35-39	961-1280	50-75	51-75
5	40-49	1281-1920	75+	76-100
6	50-59	1921+	-	-
7	60-69	-	-	-
8	70+	-	-	-

the model's estimation method.

3.2.8 Use of Crop Insurance

Crop insurance allows the producer to guarantee a minimum crop yield for the price of an insurance premium. In the event of crop failure due to natural hazards, the insurance fund pays the producer the value of any positive difference between the insured yield and the actual crop yield obtained. The net effect of crop insurance is to reduce yield uncertainty. Therefore individuals who are relatively more willing to act under conditions of risk and uncertainty can be expected to make less use of crop insurance. A producer can choose to insure for different yield levels, and against different natural hazards. The type of insurance the individual normally uses is measured by INSTYPE. An individual who indicated using the total coverage offered by the combination of all risk and hail insurance was deemed the most risk averse, and the response was assigned to a separate category. The use of all risk insurance only was considered the next least risk averse attitude and was assigned to another category. A response of hail insurance was assigned to a third, while a response indicating crop insurance was not normally purchased was considered the least risk averse and assigned to a fourth category. PINS is the proportion of total grain and oilseed acreage the respondent typically insures. The greater the amount of crop insurance an individual uses the less willing is the individual to farm under conditions of yield uncertainty. Table 3.3 gives the categorization of the PINS variable.

3.2.9 Crop Production Mix

The type of crops a farmer choses to produce are dependent on the individual's marketing habits. The majority of the grain produced in western Canada is marketed by farmer owned cooperatives. The cooperatives were established in the 1920's. Western Canadian farmers of that era believed the existing private grain marketing agents did not always offer competitive prices for the purchase of farmer's grain, nor did they always provide the type of assembly services farmers desired. Therefore farmers banded together to improve their bargaining power by forming the cooperatives. Mistrust of private grain marketers, and the associated support of cooperatives are also characteristic of some present day farmers. The crops grown by the farmer who markets through the cooperatives reflect the type of marketing services offered. The cooperatives evolved at a time when western Canada produced cereal grains almost exclusively. Consequently, the bulk of the cooperatives' trade has been, and is in the cereal grains of wheat, barley, oats, and rye. The cooperatives also market flax and canola, as well as a variety of special crops. However smaller privately owned grain companies and crop processors are responsible for the majority of special crops marketing. Therefore the farmer who adopts special crops including grain corn was hypothesized to follow less traditional marketing practices.

The development and adoption of special crops other than grain corn involves variables similar to those hypothetically involved in the development and adoption of grain corn. Consequently a farmer's adoption of special crops also measures his adoption of crop technology generally. The variable, SPECROP was used to measure the number of special crops grown per farm where special crops include potatoes, soybeans, lentils, field beans, peas, sugar beets, canary seed, winter wheat, triticale, and sunflowers. Not one of the eleven crops were grown by a majority of farmertypes, therefore the total number of special crops grown per farm was used to categorize the variable SPECROP. The variable includes three categories of none, one, or two or more special crops per farm.

Given the production of special crops can involve increased risk and uncertainty relative to the production of conventional crops, the number and area of special crops a farmer produces reflects the individual's willingness to farm under such conditions. The special crop variable, SPECROP was included in the risk equation, equation 3.1.3, of the model to outline this interaction. The ratio of acres of grain corn grown in 1983 to total acres of cultivatable land, GCORN is also included in equation 3.1.3 to outline a similar interaction. However, the proportion of grain corn to total cultivatable acres variable was also used to measure the extent of adoption. Specifically, in stage four of the adoption process outlined in Chapter 2, the individual was hypothesized to first experiment with a new crop technology on a small scale. In stage five experimentation can lead to adoption and continued use, possibly involving expanded production of the crop. The GCORN variable includes three categories, namely less than 25, 26 to 49, and 50 percent or more of total cultivatable acres in grain corn in 1983. The variable enables testing of the hypyothesis that farmers who have grown grain corn for a longer period have adopted the technology most extensively.

3.2.10 Congruence

Silage corn production is a cultural practice closely related to grain corn production. Except for the type of hybrids and harvesting methods used the cultural practices recommended for use with each crop are similar. Also, and again with the exception of harvesting equipment, silage corn production equipment can be used to produce grain corn. Therefore farmers who have previously grown silage corn are more likely to adopt grain corn than farmers who have not grown corn for silage. Furthermore, the investment required and consequently the potential financial loss is less for silage than for grain corn. Therefore, the individual may decide to try silage before grain corn. Corn that was unsuccessfully grown for grain can be harvested as silage. In total, silage corn is related to the adoption of grain corn production in two related respects. One, it is a logical precedent in the progressive adoption of grain corn technology, and two it can result from an unsuccessful attempt at grain corn production.

Survey respondents were asked whether they ever grew silage corn, and if so in what year they first did so. If the respondent indicated growing silage before grain corn, the observation was assigned to the first of two categories of the congruence variable, CONG. If the respondent had not grown silage before grain corn, the observation was included in the second category. The variable was compared between grain corn adopters only.

3.2.11 The Contingency Table

The contingency table as described by Mason, et al.. (1984) was used to test whether the characteristics, or independent variables of the interdisciplinary model differ between farmertypes and over time. The categories of the principal dependent variable ADOPTION define four farmertypes, while the categories or interval values of each independent variable measure the magnitude of a characteristic. Each characteristic has two or more dimensions and each of the three adoption samples of the model include three or more farmertypes.

The contingency table was used to test for three different relationships. One, the table was used to test whether the distribution of farmertypes in each of the three adoption groups is related to the distribution by characteristic dimension for each characteristic. The identification of a significant relationship indicated the distribution by characteristic differs between the farmertypes of the respective sample. Two, the table was used to test whether the distribution by characteristic dimension is related to the distribution of farmers by years of farming experience. The years experience categories include those delimiting each adoption group. The identification of a significant relationship is interpreted to indicate the characteristic changes with the age of the individual. Three, the table was used to test for a relationship between the dependent and independent variables of equations 3.1.2 and 3.1.3 of the model. Dependent-independent variable interactions were estimated with one table which included the total sample. The identification of significant relationship(s) was used to support the hypothetical framework of the model.

A contingency table is constructed by plotting two variables, one on the horizontal and the other on the vertical axis as in Table 3.4. The table is composed of cells, with one cell for each possible combination of the axial variables. Variable X1 has two possible values, a and b, and X2 also has two possible values, 1 and 2, therefore four combinations of variable values are possible, namely a1, a2, b1, and b2. Table 3.4 includes variables with only two values to simplify the discussion. The method is the same for variables with n values.

TABLE 3.4

The Contingency Table

		X1	
		a	b
X2	1	1 a1	2 b1
	2	3 a2	4 b2

Two events are independent when the probability of their mutual occurrence is equal to the product of the probabilities of their separate occurrence. This definition of independence is used to test for a relationship between the axial variables of a contingency table such as Table 3.4. Specifically, the probability of any one variable value occurring separately is equal to the frequency of that value in a sample of size n. For example, the probability of observing a is p(a), and is estimated by the number of times a is observed in sample n. The remaining marginal frequencies, p(b), p(1), and p(2) are similarly defined, and all four marginal frequencies are appropriately multiplied to estimate the frequency of each cell of the contingency table. For example, the expected frequency of cell 1 or the probability of observing a and 1 is p(a1), where p(a1) = p(a) x p(1). The actual frequency of a cell is equal to the number of times the cell's values are observed simultaneously in a sample n. Consequently, when the differences between the expected and actual cell frequencies of a contingency table are large, the data do not support the null hypothesis that the respective variables are independent. The occurrence of the respective variable values are different than what might be expected according to the strict definition of independence, and the occurrence or nonoccurrence of one variable is said to influence the other. The significance of the difference between the expected and actual cell frequencies is measured with the Chi-square statistic.

The power of the contingency table as a method of testing the relationship between, and describing the variation within two variables is influenced by the categorization of the respective variables. The categorization must reflect the variation inherent in the population under study, and its ability to do so is influenced by the size and representativeness of the sample involved. When the sample is such that one or more categories do not contain a sufficient number of observations to meaningfully interpret the category(s) relative to the remaining categories, two or more smaller categories can be combined into one. Such categorization enables estimation yet reduces variation and therefore the power of the contingency table.

In developing the variables of the interdisciplinary model for estimation by the contingency table method, several variables were recategorized. The division of the survey sample into three adoption samples reduced the variation in any one sample. Therefore some of the categories of the variables measuring operator age, and farm size were categorized differently for each time subsample. The model also includes four continuous variables that were not directly grouped by their associated survey form response categories. These variables were grouped into intervals, and each interval assigned a value. The variables include the three knowledge indices, namely AWARE, RECOPRAC, and CORNKNOW, and the attitude to risk and uncertainty index, RISK. The three knowledge indices were each characterized by large concentrations about specific scores, while the RISK index was characterized by more nearly continuous variation. Therefore the individual's score, as well as the number of observations were considered in the grouping of the knowledge indices' variation into approximately equal intervals. The RISK variable was grouped into three approximately equal sized intervals. The categorization of the knowledge and risk variables is intended to differentiate three distinct levels, and is presented in Table 3.5.

TABLE 3.5

Reranking of the Three Knowledge Indices and the Attitude to Risk and Uncertainty Index for Use in Contingency Table Analysis

Variable	New Rank	Old Range	Maximum Value	% Total Sample
AWARE	1	0-2		42
	2	3-4		42
	3	5	5	16
RECOPRAC	1	.25-3		55
	2	3.25-4		32
	3	4.25-5	5	13
CORNKNOW	1	2-5		41
	2	5.5-7		33
	3	7.5-9	9	26
RISK	1	0-6		28
	2	7-9		44
	3	10-12	12	28

3.3 THE SURVEY

The interdisciplinary model was used to analyze data gathered by a mail survey of Manitoba farmers, the details of which are explained in this section.

3.3.1 The Survey Region

The study was based on a survey of farmers in the western Red River Valley, Figure 3.1. This region was chosen because it was one of the first regions in the province to have grown grain corn. Furthermore, the Morden Research Station, which is the origin of grain corn technology in the province, is located in the region. Consequently the farmers of the region have had more experince with the crop, and the chances of obtaining a larger sample of adopters were higher. For example, the 1981 Census of Agriculture indicated the region contained 47.3 percent of all grain corn farms, and 48.5 percent of all grain corn acreage in the province.

The survey region was also chosen because it is characterized by approximately homogeneous agroclimatic conditions. A strip of black Chernozemic soils predominate the centre, Figure 3.1. The loam soils of the strip are the best suited to grain corn production, and consequently account for the majority of the region's corn acreage. The composition of the soils is approximately constant, therefore one dimension of the uncertainty of crop yield is constant throughout the region.

Although the soils of the strip are of similar origin, they do differ in their moisture holding capacity. The moisture holding capacity of a soil determines how much moisture is available to a growing crop via its root system. The effect of soil moisture on crop production depends on the stage of crop growth. Denmead and Shaw (1960) as cited by Dunlop (1981) have observed that moisture stress at silking reduced corn yield by 50 percent. Similarly, soil moisture stress at the heading stage can have a detrimental effect on wheat yield. Therefore Dunlop (1981) developed measures of the amount of soil moisture at the silking and heading stages as estimates of the soil capacity. Table 3.6 includes these parameters which delineate four subregions of different soil moisture holding capacity within the survey region, Figure 3.1. Subregion 4 has the finest textured soils as evidenced by the higher average, and less variable soil moisture conditions. Subregion 3 has the most porous soils and therefore is the most likely to exhibit moisture stress on crop production. Moisture stress can be expected in each subregion in at least one out of every ten years.

Each of the four soil moisture subregions can be identified with a unique set of heat characteristics. Dunlop (1981) has also measured the

TABLE 3.6

Agroclimatic Characteristics of the Survey Region

Characteristic	Subre-gion 1	Subre-gion 2	Subre-gion 3	Subre gion 4
CHU Accumulation				
5/10 years	2627	2501	2434	2545
7.5/10 years	2481	2353	2303	2391
9/10 years	2349	2215	2183	2250
GDD Accumulation				
5/10 years	1758	1657	1646	1662
7.5/10 years	1663	1582	1558	1583
9/10 years	1577	1514	1477	1509
Soil Moisture at Silking in Corn, (in.)				
5/10 years	25	24	12	35
7.5/10 years	-3	0	-16	12
9/10 years	-28	-22	-41	-10
Soil Moisture at Heading in Wheat, (in.)				
5/10 years	33	34	26	36
7.5/10 years	8	9	-3	11
9/10 years	-15	-14	-29	-11

see Figure 3.1 for subregions

heat resources of the survey region. The amount of heat available for corn production is measured by the Corn Heat Unit, CHU. Normally 2300 CHU's per growing season are required to grow the hybrids available in Manitoba. Table 3.6 indicates CHU accumulation is more variable in Subregions 2 to 4 with each subregion receiving less than the required 2300 units in at least every one in ten years. The amount of heat available for cereal grain production is measured by the Growing Degree Day, GDD. Normally 1200 GDD's per growing season are required for wheat production. Table 3.6 indicates that each subregion can be expected to receive sufficient heat for wheat production in ten years out of every ten.

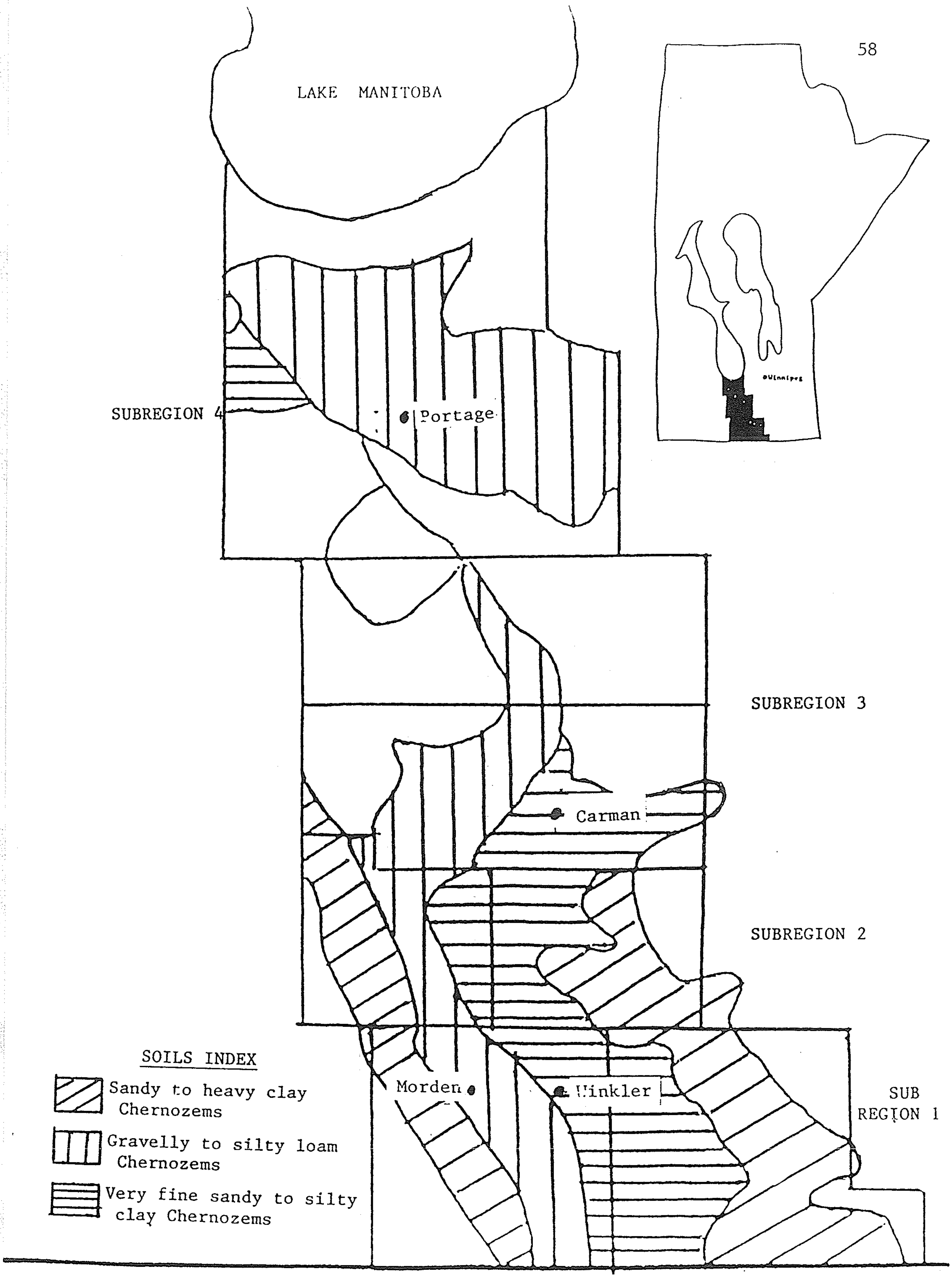

Figure 1: Survey Region, Subregions, and Soiltypes

3.3.2 The Survey Method

Two precepts were followed in gathering data by survey. One, the survey should not duplicate existing information, and two the survey instrument should be as unobtrusive as possible. To this end, the survey did not gather information that had already been collected by the Canadian Census of Agriculture, with the exception of two variables. These two variables, farm size and operator age, were included so that the representativeness of the sample could be determined.

The survey form or instrument was developed with the consultation of two sources. The first source included provincial government extension bulletins and personnel, and private input retailers consulted in developing questions on the use of recommended grain corn and grain growing practices. The second included previous survey research reports, such as Hobbs et al. (1964) and Ramsey et al. (1959) that discussed the dimensions involved in measuring attitude to risk and uncertainty in farming. Two versions of the form were used. The first version included five more questions on recommended grain corn growing practices than the second version and is presented in Appendix A. The second version did not include questions 6, 7, and 9 to 11. The survey instrument was pretested with a sample of five corn growers located throughout the survey region.

The first version of the form was sent to members of the Manitoba Corn Growers Association, MCGA. The MCGA had 276 members in the survey region in 1983. The second version of the survey was sent to farmers identified by land ownership maps of the municipalities involved. Members of the MCGA were located on the maps, and an equal number of non-members per municipal township was randomly selected. Characteristics of the population are given in Table 3.7. Farms reporting wheat are farms that grow traditional cereal grain and oilseed crops. Wheat farms

TABLE 3.7

1981 Characteristics of the Population

Characteristic	Grain Corn Farms	Wheat Farms
Farm Size (acres)		
Average	914.0	626.0
Std. Dev.	706.0	541.0
Operator Age (years)		
Average	39.8	44.8
Std. Dev.	12.1	13.3
Farm Capital ($)		
Average	424900.0	367700.0
Std. Dev.	117356.0	141200.0
% land & buildings	80.5	70.8
% machinery	16.2	15.2
% livestock & poultry	3.3	14.0
Sales Class ($)		
Average	115230.0	70545.0
Std. Dev.	80870.0	65840.0
Tenure	21.8	40.9
% own only	21.8	40.9
% own & rent	65.3	49.5
% rent only	12.9	9.6
Off Farm Work		
% working off	31.4	24.0

Source: 1981 Census of Canada, Agriculture, Manitoba Statistics Canada, Cat. No. 96-908

are assumed to represent nonadopters.

The initial mailout contacted 208 MCGA members and 208 nonmembers alike, and resulted in a 37 and 20 percent response rate for members and nonmembers respectively. Consequently, a second mailout was completed three weeks after the first. The second mailout contacted 150 of the initial 208 MCGA members, all 208 initial nonmembers, plus an additional 68 members and 68 nonmembers. Fifty-eight of the initial 208 MCGA members were not contacted a second time because the initial response was deemed representative of the subregions concerned. Specifically, the initial response from MCGA members in subregions 2 and 4 averaged 80 percent. Because of the poor response rate for both members and nonmembers in the remaining subregions it was also deemed necessary to expand the sample in the second round despite the fact this introduced a bias to the sample, (Macpherson (1984)).

3.3.3 Representativeness of the Survey Sample

The survey resulted in an overall average response rate of 36 percent. The response from MCGA members, at 44 percent was greater than the response from nonmembers at 28 percent. After accounting for spoiled and incomplete replies this response rate resulted in a usable sample of 114 corn growers and 59 noncorn growers. The sample includes 25 percent of the 1981 population of grain corn growers, and 3 percent of the 1981 population of nonadopting farmers within the survey region, (Statistics Canada, Special Request (1981)). Table 3.8 reports the results of comparing selected structural charateristics of the survey sample with those of the 1981 Census of the survey region. The table includes expected and actual frequencies of farm size and operator age items. The expected frequency is that observed in the Census, while the actual is that observed in the sample. Any difference between the two entries indicates a possible bias in the sample. The significance of the difference is estimated with the Chi-Square statistic. The Chi-square statistics for both corn and wheat sample's farm size are greater than the 95 percent critical value of 2.17, as are the Chi-squares for age which has a 95 percent critical value of 1.64. Therefore the sample's distribution of age and farm size characteristics is not the same as the population's distribution.

Table 3.8 includes the entry Percent Representation, (PR) to identify the relative bias of the sample. PR is equal to the difference between the expected and actual divided by the expected frequency. The sign of the PR entry indicates whether the sample contains too many, (positive) or too few, (negative) observations in the respective category. The corn grower sample contains too few farmers in the 15 to 24, 50 to 59, and 60 to 69 year age categories, and too many observations in the 35 to 39, 40 to 49, and 70 years and over categories. This bias is reflected in the corn grower sample's distribution by farm size by too few farms under 400, and over 2880 acres, and too many farms in the 1600 to 2879 acre range. In summary, the grain corn adopter sample is principally biased by too many 35 to 49 year old farmers operating 1600 to 2879 acre farms.

The noncorn grower sample contains too few farmers 15 to 29, 40 to 49, and 60 to 69 years old, and too many 35 to 39, and 50 to 59 year old farmers, while also including too few farms under 70, between 1120 and 1599, and over 2880 acres, as well as too many 760 to 1119 acre farms. In total, the noncorn grower sample notably contains more 35 to 39 year olds, and fewer farmers under 29 and between 60 to 69 years operating

TABLE 3.8

Representativeness of Survey Sample

Age Frequency Range	Corn Growers Expected	Corn Growers Actual	Percent Representation	Non Corn Growers Expected	Non Corn Growers Actual	Percent Representation
15-24 years	9	3	-67	3	1	-67
25-29	18	18	0	6	3	-50
30-34	17	18	6	6	6	0
35-39	15	22	35	6	11	83
40-49	25	29	16	15	12	-20
50-59	21	16	-24	15	18	20
60-69	8	4	-50	9	6	-33
70+	1	3	200	2	2	0
CHI-SQUARE		26.0			3.4	
MEAN	39.8	44.8		40.0	47.4	
STD. DEV.	12.1	13.3		11.3	12.8	
NO.	455	114	25	2060	59	3

Size Frequency Range	Expected	Actual	Percent Representation	Expected	Actual	Percent Representation
<70 acres	2	0	-100	2	1	-100
70-239	11	5	- 55	11	12	9
240-399	13	8	- 38	13	13	0
400-559	14	16	14	12	11	- 8
560-759	23	21	-9	11	10	- 9
760-1119	22	25	14	7	9	29
1120-1599	13	14	8	3	1	- 67
1600-2879	12	22	83	2	2	0
2880+	4	3	-25	1	0	-100
CHI-SQUARE		21.9			6.32	
MEAN	914	1098		626	546	
STD. DEV.	706	541		508	430	
NO.	455	114	25	2060	62	3

1120 to 1599 acre farms than does the 1981 population of the survey region.

3.4 THE ECONOMIC MODEL

This section follows Griliches (1957) in developing the decision making model of Chapter 2 into a model to test the importance of profitability in explaining the adoption of grain corn in Manitoba. Griliches (1957) defined the adoption of hybrid seed as the percentage, P of corn acreage planted with hybrid seed. Griliches plotted P over time and observed that the resultant curve did not represent a point of equilibrium but more accurately depicted an adjustment path moving toward a new equilibrium. Therefore, Griliches fit the following trend function to P, estimated the function for different geographical areas, and compared the resultant differences in the estimates of the parameters of the function.

$$P = K/(1+e)^{(-a+bt)} \qquad (4)$$

While P is the percentage planted with hybrid seed, K is the maximum value that P can attain. K restricts P to land that was previously used to grow open pollinated varieties of corn. Time is represented by t, b is the rate of growth, and a is the constant of integration. Griliches transformed the logistic into a linear function by taking its logarithm, $\log(P/(K-P)) = a+bt$, after adjusting for the differences in K. Griliches regressed $P/(K-P)$ on time, t to obtain estimates of b, the rate of adoption. Griliches regressed the estimate of the rate of adoption, b for each of 31 American states on a cross section of the expected per acre profitability of hybrid corn in each state. Griliches also regressed b for each of 132 U.S. crop reporting districts on a cross section of the expected profitability in each crop reporting district.

Profitability was defined as the increase in yield due to the use of hybrid seed. Griliches included independent variables other than profitability in each of the cross sectional regressions but found that profitability was superior in explaining the variation in the rate of adoption of hybrid corn seed.

The following model was used to examine the role of profitability in the adoption of grain corn in the survey region. The model is a synthesis of Griliches work and the crop decision model of Chapter 2. The model was estimated by the OLS method from a cross section of observations from each of the four subregions for the years 1970 to 1982.

$$(5)\quad CORNSHARE_{it} = PROFIT_{it} + SOF_{it} + HYBRID_{it} + D2_{it} + D3_{it} + D4_{it} + RATIO2_{it} + RATIO3_{it} + RATIO4_{it}$$

where i = 1...4 survey subregions

t = time, 1970-82

CORNSHARE = grain corn area/total area under crop

PROFIT = ratio of dollar per acre net profitability of grain corn to wheat production before capital costs

SOF = stocks of 6 principal CWB grains on Manitoba farms on March 31, million bushels

HYBRID = number of commercial hybrid grain corn seed varieties available per year

D2 = 1 when CORNSHARE = rate for Subregion 2, 0 otherwise

D3 = 1 when CORNSHARE = rate for Subregion 3, 0 otherwise

D4 = 1 when CORNSHARE = rate for Subregion 4, 0 otherwise

RATIO2 = profitability ratio, (PROFIT) for Subregion 1 when CORNSHARE = rate for Subregion 2

RATIO3 = profitability ratio, (PROFIT) for Subregion 1 when CORNSHARE = rate for Subregion 3

RATIO4 = profitability ratio, (PROFIT) for Subregion 1 when CORNSHARE = rate for Subregion 4

Like the area of Griliches study Table 1.1 suggested the production of grain corn in Manitoba has been following a path of adjustment. However, unlike the area of Griliches' study hybrid grain corn acreage did not replace open pollinated variety acreage. Rather, grain corn production replaced the production of a variety of crops. Therefore CORNSHARE was specified as the ratio of acres in grain corn to the total acreage of all crops for each subregion. As such CORNSHARE is defined as the rate grain corn was adopted in replacement of all crops. Appendix E discusses how the acreage figures used to estimate CORNSHARE were obtained.

The six principal crops whose market delivery is regulated by the Canadian Wheat Board are the most extensively grown crops in western Canada. Of these six wheat is the most universally grown and was used as the benchmark in developing the PROFIT variable. PROFIT is the ratio of the per acre profitability of grain corn relative to wheat. PROFIT is designed to estimate the notion that a new technology must not only be profitable, but more profitable than existing technology in order to be adopted.

The factors determining profitability cannot be preknown with certainty therefore the decision maker must form expectations of profitability. The dollar per acre grain corn and wheat profitability components used in constructing PROFIT were specified to simulate the expectations a farm decision maker might form when making cropping plans in the spring of the year. Both wheat and grain corn components were constructed in the same fashion. Since price is not known with certainty, the price of the previous year is used as an estimate. A five year moving average of the corn and wheat yield, (MCIC records) obtained in each subregion was used as an estimate of expected yield. This approach captures the gradual increase in yield that has come to be expected as a result of improved cultural practices and increased petrochemical input use. It is also consistent with the potential grower who consults local growers and personal experience for information on yield performance. Farmers are well aware of the variable effect that agroclimatic conditions have on output levels. Therefore they are more apt to form expectations on the results of several years instead of a single year's experience with a new crop. Unlike price and yield, the decision maker can consult farm supply outlets at seeding time to estimate with relative certainty the costs of production for the immediate crop year. Only cash costs are included because the model is concerned with expected annual profitability. More precisely, the magnitude of investment in fixed costs is such that annual profitability is considered over a period of years. The decision maker can use the model as specified to estimate annual profitability, and then use annual estimates to determine the number of years required to recoup fixed investment costs. This time period can be thought of as the decision horizon.

The model uses wheat to represent the opportunity cost of deciding to grow grain corn. Specifically, the per acre profitability of wheat is assumed to represent the revenue from the production of all existing crops that must be given up in order to grow grain corn. In order for grain corn to be adopted the opportunity cost of growing other crops cannot be greater than the expected profitability of growing grain corn. Since the six CWB grains are the principal crops that grain corn competed with there is another dimension of opportunity cost to consider. Grain corn is not a CWB crop, and as a nonBoard grain the sale and delivery of corn is not directly regulated by CWB quota as it is for the six principal grains. Under this regulation the producer of any one or a combination of the six grains must register eligible farm area with the CWB in the springtime. The producer must then decide the proportion of eligible acreage to assign to the delivery of each of these grains. The delivery of grain is regulated by quota. For example, suppose a farmer has 100 eligible acres, 20 of which is assigned and registered with the CWB for the delivery of wheat. A CWB delivery quota of 10 bushels of wheat would allow the farmer to sell 20 acres x 10 bushels = 200 bushels of wheat.

The number of eligible acres is determined by formula. This formula was changed slightly at the beginning of the 1982-83 crop season. Prior to this the last major change was in the 1971-72 season. Therefore the 71-72 formula was in effect over the period in which grain corn production increased in Manitoba. Under the 71-72 formula the total number of acres that were eligible or that could be assigned to the delivery of the six Board grains included all acres seeded to the six Board grains + all summerfallow acres + all nonBoard crop acres + all forage acres. The number of forage acres could not exceed one third of the total of the first three categories.

The CWB determines delivery quota according to the sale of Board grains. More precisely, the Board monitors the export and domestic sale of the six grains. When grain is needed to fulfill sale committments the Board determines how much is on hand at terminal storage locations and how much if any must be moved out of country locations. The total amount that must be moved out of country locations is divided by the number of producers who assigned acreage to the crop for that year. This quantity is the amount that each producer is eligible to deliver. This method works fine in years of large sales and/or low production. However, when the country produces more grain that it is able to sell producers are unable to deliver their Board grains, thereby incurring costs of storage and opportunity on foregone revenue. The assignable acreage fomula provides an avenue for reducing these costs. Specifially, by increasing production of nonBoard crops a farmer can deliver a larger proportion of Board, as well as sell nonBoard crop production. Therefore, and especially in years of relatively small grain sales and/or large production, the central marketing system of the CWB acts as an incentive to nonBoard crop, including grain corn production.

The opportunity cost of holding grain stocks variable, SOF is intended to measure the impact of CWB policy on the production of special crops. The variable is specified to capture the opportunity cost of unsold principal grains as perceived by the farmer. The farmer in making spring cropping plans is assumed to consider not only the price but also marketing opportunities. Should considerable stocks of a particular grain or grains from the production of previous years still be on hand the possibility of selling the upcoming years production is decreased. Consequently, the larger the stocks on hand the greater the revenue foregone, the poorer the potential for delivery in the upcoming year, and the greater the incentive to grow crops not subject to the same market regulation. The SOF variable is equal to the total stocks of the six principal grains on all Manitoba farms at March 31 of each year. The CWB quota delivery policy described previously guarantees each Prairie farmer the opportunity to deliver an equal proportion of principal grain production. Therefore the survey region's share of all stocks of principal grains in the province can be assumed to be relatively constant over time.

The variable HYBRID includes the number of hybrid grain corn seed varieties available each year over the period 1970 to 1982. The number and variation in the characteristics of grain corn hybrids increased from a low of 15 in 1970 to a high of 25 in 1982. The hybrid seed varieties were developed to suit a greater number of agroclimatic conditions. Therefore the number and type of varieties available determine whether grain corn is suited to, and adopted at a particular location. In summary, the HYBRID variable measures the annual number and variety of grain corn hybrids, and is included in the model to account for the effect availability of technology has on adoption.

3.4.1 Spatial Considerations

The provincial crop insurance acreage records used to estimate the profitability model indicate Subregions 1 and 2 were the first to grow grain corn on a consistent annual basis, beginning in the mid 1960's. This was followed by Subregion 3 in the early 1970's and Subregion 4 in the mid 1970's. There are several possible reasons for this pattern of adoption. One reason is the availability of grain corn technology. The

Morden Research Station is located in Subregion 1, close to the boundary between Subregions 1 and 2, Figure 3.1. Hybrid seed developed at the Station would have been suited to Subregions 1 and 2. However Table 3.6, which presents the agroclimatic characteristics of the subregions, does not conclusively support this inference. Specifically, while Subregion 1 receives the greatest number of CHU's, Subregion 4 receives more CHU's than Subregion 2. Similarly, Subregion 4 exhibits the least moisture stress followed by Subregion 1. These characteristics suggest hybrids suited to Subregions 1 and 2 should have also been suited to Subregion 4, yet Subregion 4 did not begin producing grain corn on a regular basis until the mid 1970's. Moreover, Subregion 3 receives the least number of CHU's and exhibits the greatest moisture stress, yet it began regular grain corn production before Subregion 4. In summary, the agroclimatic characteristics of the subregions suggest reasons other than the availability of suitable hybrid seed may have influenced the spatial path followed by adoption.

One possible reason for the pattern followed by grain corn adoption in the survey region concerns the relative subregional profitability of grain corn. Agronomic conditions largely determine yield, which in turn influence crop profitability. The profitability model was specified to compare the relative role of profitability in determining the subregional rate of adoption. As mentioned, crop acreage records and the location of the Morden Research Station indicate Subregion 1 was the centre of grain corn innovation. Therefore variables RATIO2, RATIO3, and RATIO4 are equal to Subregion 1's corn to wheat profitability ratio, PROFIT when the dependent variable is equal to the corn to total cultivatable land ratio in Subregions 2, 3, and 4 respectively, and 0 otherwise. If profitability was of different importance in affecting adoption in any of Subregions 2, 3, and 4 relative to Subregion 1, the significance of the RATIO2, RATIO3, and, RATIO4 coefficients will indicate such.

There are reasons other than the availability of hybrid seed and the profitability of grain corn that may have accounted for the path followed by grain corn adoption. The profitability model includes three dummy variables, D2, D3, and D4 to test for the existence of other factors. The dummy variable D2 was set equal to 1 when the dependent variable was equal to the acreage ratio in Subregion 2, and 0 when CORNSHARE was equal to the ratio in the remaining subregions. Variables D3 and D4 are similarly defined for their respective Subregions 3 and 4. Should intersubregional factors other than the availability and profitability of grain corn technology, and the opportunity cost of principal grain stocks have influenced the adoption rate, such factors will express themselves in the size and significance of the D2, D3, and D4 coefficients.

Another possible reason for the path followed by adoption that is related to profitability concerns the relative risks involved. As discussed with reference to Table 3.6, Subregion 3 receives the least CHU's and has the most porous soils of the region. Subregion 3 therefore appears to be the riskiest region in which to grow corn, yet Subregion 3 adopted before Subregion 4. One possible reason why Subregion 3 adopted before Subregion 4 has to do with producer's attitude to risk and uncertainty. Specifically farmers of Subregion 3 may be, or were less risk averse than farmers of Subregion 4. Therefore, the distribution of survey respondent location by score on the index measuring attitude to risk and uncertainty, RISK was examined.

The individual's position on the adoption path determines the amount of information available. The least information is available to the innovator, sequentially followed by the adopters. The amount of available information concerning a specific technology may also be a function of the type of information source(s) used. Specifically, Subregion 3 and 4 farmers may have adopted after Subregions 1 and 2 because they use different sources of information. Therefore score on the three knowledge and the use of information indeces was compared between farmertypes of each subregion.

3.5 SUMMARY

This chapter developed the methods used to test the theoretical considerations of adoption presented in Chapter 2. The first method included the interdisciplinary model designed to fulfill three purposes. One, the model is designed to identify the socioeconomic, psychological, and use of information characteristics of grain corn adopters and nonadopters. Two, the model examines characteristic interactions within farmers, and three the model examines whether characteristics change with farmer age and over time as the state of technological development increases. The data analyzed by the interdisciplinary model includes a survey sample of grain corn adopters and nonadopters in the leading grain corn growing region of the province. The survey region and method, and the potential problems of examining adoption that occurred in the past with static survey data were also discussed.

The second method included the economic model. The economic model is designed to determine the importance of the relative profitability of grain corn production, the opportunity cost of noncorn stocks of grain on farms, and the availability of hybrid grain corn seed on the adoption of grain corn in the survey region between 1970 and 1982. The model also examines the relative importance of profitability on adoption in each of four subregions within the survey region, and whether factors other than the three aforementioned independent variables explain the adoption of grain corn in each of the survey subregions.

Chapter IV

RESULTS AND ANALYSIS

This chapter contains the results of estimating the models developed in the previous chapter. The results of the interdisciplinary model are individually reported for each independent variable, and are followed by the results of the economic model. The results of each model are then combined in an interpretation and summary of their interaction in the adoption process.

4.1 THE INTERDISCIPLINARY MODEL

This section presents the results of following the interdisciplinary model to identify the socioeconomic, psychological, and use of information characteristics of farmers. The results are reported in the approximate order the respective variables were included in the model. The model tested for three different types of variable interactions. One, the model tested for a farmertype-characteristic relationship within three subsamples, each of which is consistent with a specific period in the history of grain corn production in Manitoba. A significant farmertype-characteristic relationship in any one subsample is interpreted to indicate the characteristic was a notable factor during the adoption period relative to any subsample(s), or adoption period group(s) where a farmertype-characteristic relationship was not found. Two, the model tested for a number of years farming experience-characteristic relationship. A significant result is interpreted as evidence the characteristic changes within an individual over time. Three, the model tested for selected characteristic-characteristic relationships for the total sample. Significant relationships are used to identify notable variable interactions in the interpretation of the results presented in the final section of the chapter.

The principal dependent variable and the time dimension of the model were used to categorize the data sample by farmertype and years of farming experience. Table 4.1, which presents the distribution of farmertypes by years of farming experience, introduces the type and number of survey sample farmers included in each adoption period group of the model. The table contains three contingency tables, one for each adoption period. Adoption group 3 includes farmers who began farming, and therefore adopted grain corn in 1970 or later. Group 3 does not include innovators because innovators were defined as individuals adopting before 1970. Group 2 includes all four farmertypes with 14 to 29 years of farming experience. Four farmertypes with 30 or more years of farming experience are included in group 1. Innovators in groups 1 and 2 are respectively labeled 1 and 2 to indicate both farmertypes adopted similar technology but under different total provincial acreage conditions. The Number column on the right hand side of the table indicates the number of observations in each farmertype category and adoption period group. The Chi-square statistic beside each of the three adoption period tables indicates whether the respective distribution of farmertypes is related to the variable in question. The Chi-square in the last row of the table indicates whether the respective variable is related to farming experience.

TABLE 4.1

Percent Distribution of Farmertypes by Number of Years Farming Experience

Adoption Period (No. Years Farming)	Farmer Type	Number of Years Farming			Per- cent	Num ber	Chi- Square
		1- 6	7-13				
1970-1982	Nonadopter	43	57		100	14	
(1-13 yrs)	Late Adopter	44	56		100	34	
Group 3	Early Adopter	0	100		100	11	7.76*
	Percent	36	64		100	59	
		14-20	21-25	26-29			
1954-1969	Nonadopter	48	26	26	100	27	
(14-29 yrs)	Late Adopter	59	29	21	100	24	
Group 2	Early Adopter	60	23	17	100	13	
	Innovator-2	33	44	23	100	9	3.94
	Percent	51	29	20	100	73	
		30-34	>34				
pre 1954	Nonadopter	11	89		100	18	
(30+ yrs)	Late Adopter	60	40		100	5	
Group 1	Early Adopter	56	44		100	9	
	Innovator-1	33	67		100	9	7.56
	Percent	32	68		100	41	

* significant at the 95% level.

Table 4.1 is included principally to introduce the categorization of the data and the tabular format used to present the remainder of the results. Table 4.1 also gives a more detailed categorization of farming experience than that used as the time dimension of the model. The Chi-square statistics in the right most column of the table indicate a relationship between years farming experience and farmertype exists for adoption group 3 only. This observation is due to the definition of early adopters wherein early adapters first grew grain corn between 1970 and 1977, and therefore must have seven or more years farming experience. Other than this definitional relationship, the lack of significant results indicates the three groups of the model include farmertypes with insignificantly different amounts of experience. Therefore the division successfully removes the variability experience may introduce to subsequent analysis.

4.1.1 Representativeness of the Sample

The results of examining farm operator age and farm size are included at this point to outline the bias of the sample. Table 3.8 outlined the degree to which the survey sample of adopters and nonadopters represent their respective 1981 Census populations. This information can be applied to Table 4.2, which presents the distribution of farmertype by age, and to Table 4.3 which presents the distribution of farmertypes by farm size, to detail the sample bias within the farmertype definitions used. Table 3.8 indicated the adopter sample is principally biased by disproportionately more 35 to 49 year old farmers operating 1600 to 2879 acre farms than is found in the population. This overrepresentation can be noted in the number of early and late adopters in groups 2 and 3 of Tables 4.2 and 4.3. The small nonadopter sample primarily underrepresents farmers under 29 and between 60 and 69 years, and farms between 1120 and 1599 acres, as well as overrepresents 35 to 39 year old farmers. This underrepresentation can be noted in the number of nonadopters under 29 years in groups 2 and 3, and the number of nonadopters 60 years and over in group 1 of Table 4.2. The underrepresentation of 1120 to 1599 acre farms can be noted in the nonadopters of all the groups of Table 4.3. Lastly, the overrepresentation of 35 to 39 year olds can be noted in groups 1 and 2 of Table 4.2. In total, the bias of the sample principally expresses itself in a disproportionately larger number of 35 to 39 year old nonadopters, and 35 to 49 year old early and late adopters farming 1600 to 2879 acre farms.

TABLE 4.2

Percent Distribution of Farmertypes by Age

Adoption Period (No. Years Farming)	Farmer Type	Age Category (yrs)				Percent	Number	Chi-Square
		<29	30-34	35-39	>40			
1970-1982	Nonadopter	21	29	21	29	100	14	
(1-13yrs)	Late Adopter	47	26	18	9	100	34	
Group 3	Early Adopter	27	19	27	27	100	11	6.0
	Percent	36	25	20	19	100	59	
		<29	30-39	40-49	>50			
1954-1969	Nonadopter	4	37	33	26	100	27	
(14-29 yrs)	Late Adopter	8	25	46	21	100	24	
Group 2	Early Adopter	0	54	31	15	100	13	
	Innovator-2	0	22	56	22	100	9	6.1
	Percent	4	34	40	22	100	73	
			40-49	50-59	>60			
pre 1954	Nonadopter		0	61	39	100	18	
(30+ yrs)	Late Adopter		0	100	0	100	5	
Group 1	Early Adopter		44	12	44	100	9	
	Innovator-1		0	33	67	100	9	23.9*
	Percent		10	49	41	100	41	

* significant at the 95% level.

The following discusses Table 4.2 while a discussion of Table 4.3 is postponed until section 4.1.3 so that the order of the interdisciplinary model is maintained. The Chi-square statistics of Table 4.2 indicate farmertypes of group 1 who have 30 or more years farming experience differ significantly in age. The notable concentrations include 61 percent of nonadopters and 100 percent of late adopters between 50 and 59 years, 44 percent of early adopters between 40 and 49 years, and 67 percent of innovators 60 years and over. Two concentrations can be attributed to the sample bias, while the remaining two identify an age difference. Specifically, the concentration of nonadopters may be due to the sample's underrepresentation of farmers 60 years and over, while the concentration of early adopters may be due to the sample's overrepresentation of 40 to 49 year olds. In total, the table indicates innovators of the period were older than farmers who were also farming at the time, but who adopted during the most recent Manitoban grain corn production expansion period. A Chi-square is not found in the bottom row of Table 4.2 because the age categories used in each adoption group cannot be directly compared via the contingency table. The age categories employed reflect the fact average age significantly increases from 31.9 years in group 3, to 42.8 in group 2, and 58.2 years in group 1.

TABLE 4.3

Percent Distribution of Farmertypes by Area Under Crop and Summerfallow in 1983

Adoption Period (No. Years Farming)	Farmer Type	Acres Under Crop and Summerfallow, 1983				Per-cent	Num ber	Chi-Square
		<321	321 -640	641- 1280	> 1280			
1970-1982	Nonadopter	58	21	21	0	100	14	
(1-13 yrs)	Late Adopter	9	23	41	27	100	34	
Group 3	Early Adopter	9	38	27	26	100	11	18.2*
	Percent	20	25	35	20	100	59	
1954-1969	Nonadopter	26	41	26	7	100	27	
(14-29 yrs)	Late Adopter	4	25	26	45	100	24	
Group 2	Early Adopter	8	8	53	30	100	13	
	Innovator-2	22	22	56	0	100	9	22.7*
	Percent	15	27	34	24	100	73	
pre 1954	Nonadopter	56	17	27	0	100	18	
(30+ yrs)	Late Adopter	0	60	20	20	100	5	
Group 1	Early Adopter	11	11	22	56	100	9	
	Innovator-1	0	33	33	33	100	9	23.5*
	Percent	27	24	27	22	100	41	
	Percent	20	26	32	22	100	173	3.4

* significant at the 95% level.

4.1.2 Knowledge

Table 4.4 presents the distribution of farmertype by score on the index measuring awareness of grain corn technology, AWARE and reports a significant Chi-square for each group, but not between groups. These results indicate the score the individual obtained on the awareness index is related to the type of farmer the individual is, but not to farming experience. A significantly larger proportion or 64, 92, and 88 percent of nonadopters in groups 3, 2, and 1 respectively of Table 4.4, scored 1 on the index relative to the adopting farmertypes. In group 1 none of the late adopters scored 3, and none of the innovators scored 1 on the index. In summary, Table 4.4 indicates that as of 1983 nonadopters are significantly less aware of grain corn technology than are adopters. Preliminary analysis of the awareness index score indicated that while nonadopters are less aware than adopters, nonadopters did not score so low as to suggest they are ignorant of grain corn technology.

Table 4.5 reports the distribution of farmertypes by score on the index measuring the use and knowledge of recommended crop management practices, RECOPRAC. The distribution of farmertypes by score obtained on the index is not significantly different between the farmertypes of each adoption group. The Chi-square in the final row of Table 4.5 indicates score on the index is related to years farming experience. Specifically, the proportion of individuals scoring 1 decreases from 61 percent in group 3, to 56 percent in 2, and 46 percent in group 3, while the proportion scoring 3 increases from 7 percent in group 3 to 25 percent in group 1. In total, Table 4.5 indicates the current use of recommended crop management practices does not differ between farmertypes, but that the use of such practices increases with farming experience.

Table 4.6 presents the distribution of farmertypes by the score obtained on the index measuring knowledge of grain corn production techniques, CORNKNOW. The table includes only adopting, and not the nonadopting farmertypes because the index was developed from questions

TABLE 4.4

Percent Distribution of Farmertypes by Score on the Index Measuring Awareness of Grain Corn Technology, AWARE

Adoption Period (No. Years Farming)	Farmer Type	AWARE Index Score			Per cent	Num ber	Chi-Square
		1	2	3			
1970-1982	Nonadopter	64	29	7	100	14	
(1-13 yrs)	Late Adopter	18	62	20	100	34	
Group 3	Early Adopter	20	50	30	100	11	11.8*
	Percent	31	51	18	100	59	
1954-1969	Nonadopter	92	4	4	100	27	
(14-29 yrs)	Late Adopter	21	58	21	100	24	
Group 2	Early Adopter	23	46	31	100	13	
	Innovator-2	22	67	11	100	9	36.4*
	Percent	48	37	15	100	73	
pre 1954	Nonadopter	88	6	6	100	18	
(30+ yrs)	Late Adopter	40	60	0	100	5	
Group 1	Early Adopter	33	56	11	100	9	
	Innovator-1	0	67	33	100	9	27.2*
	Percent	51	37	12	100	41	
	Percent	42	42	16	100	173	5.8

* significant at the 95% level.

included in the version of the survey sent to corn growers only. The score on the index is not dependent on farmertype in any one, nor between the three adoption groups. This indicates adopters' experience with growing grain corn is not related to their current knowledge of the technology.

TABLE 4.5

Percent Distribution of Farmertypes by Score on the Index Measuring Knowledge and Use of Recommended Crop Management Practices, RECOPRAC

Adoption Period (No. Years Farming)	Farmer Type	RECOPRAC Index Score			Per-cent	Num ber	Chi-Square
		1	2	3			
1970-1982	Nonadopter	43	57	0	100	14	
(1-13 yrs)	Late Adopter	68	21	11	100	34	
Group 3	Early Adopter	64	36	0	100	11	8.0
	Percent	61	32	7	100	59	
1954-1969	Nonadopter	67	30	3	100	27	
(14-29 yrs)	Late Adopter	50	42	8	100	24	
Group 2	Early Adopter	38	38	24	100	13	
	Innovator-2	67	22	11	100	9	7.2
	Percent	56	34	10	100	73	
pre 1954	Nonadopter	67	27	6	100	18	
(30+ yrs)	Late Adopter	60	20	20	100	5	
Group 1	Early Adopter	11	33	56	100	9	
	Innovator-1	33	33	33	100	9	7.9
	Percent	46	29	25	100	41	
	Percent	55	32	15	100	173	9.5*

* significant at the 95% level.

4.1.2.1 Information

Table 4.7 presents the distribution of farmertype by the use of information. The table indicates the pattern of information use is related to farmertype for adoption group 3 only. Specifically, more or 73 percent of early adopters use public sources of information more fre-

TABLE 4.6

Percent Distribution of Adoptertypes by Score on the Index Measuring Knowledge of Corn Production Techniques, CORNKNOW

Adoption Period (Years Farming)	Farmer Type	CORNKNOW Index Score			Per-cent	Num ber	Chi-Square
		1	2	3			
1970-1982 (1-13 yrs)	Late Adopter	32	44	24	100	34	
	Early Adopter	46	27	27	100	11	1.7
	Percent	36	40	24	100	45	
1954-1969 (14-29 yrs) Group 2	Late Adopter	42	38	20	100	24	
	Early Adopter	55	15	30	100	13	
	Innovator-2	44	33	23	100	9	2.1
	Percent	46	30	24	100	46	
pre 1954 (30+ yrs) Group 1	Late Adopter	60	20	20	100	5	
	Early Adopter	44	33	23	100	9	
	Innovator-1	22	22	56	100	9	3.6
	Percent	39	26	35	100	23	
	Percent	40	33	27	100	114	2.9

* significant at the 95% level.

quently relative to 57 percent of non and 56 percent of late adopters who use private information sources more frequently. This significant result highlights a pattern that is evident, but not significant in the remaining adoption groups. The majority of late adopters in each of the three adoption groups use private information most frequently, while the majority of early adopters and innovators in each of the three groups use public information most frequently. Nonadopters in group 1 also use public information most frequently. In summary, Table 4.7 indicates that if a farmers' current use is reflective of past information use, then the public sector is an important source of information for individuals who adopted immediately after the innovation period. Table 4.7 also indicates the pattern of information use is not statistically different between farmers with different amounts of farming experience.

TABLE 4.7

Percent Distribution of Farmertypes by Information Source Most Frequently Consulted

Adoption Period (No. Years Farming)	Farmer Type	Most Frequently Consulted Source			Percent	Number	Chi-Square
		Private	Public	Personal			
1970-1982 (1-13 yrs) Group 3	Nonadopter	57	43	0	100	14	
	Late Adopter	56	44	0	100	34	
	Early Adopter	18	73	9	100	11	11.4*
	Percent	49	49	2	100	59	
1954-1969 (14-29 yrs) Group 2	Nonadopter	56	37	7	100	27	
	Late Adopter	54	38	8	100	24	
	Early Adopter	30	55	15	100	13	
	Innovator-2	22	78	0	100	9	6.9
	Percent	47	45	8	100	73	
pre 1954 (30+ yrs) Group 1	Nonadopter	17	72	11	100	18	
	Late Adopter	60	40	0	100	5	
	Early Adopter	33	56	11	100	9	
	Innovator-1	44	44	12	100	9	4.7
	Percent	32	59	8	100	41	
	Percent	44	50	6	100	173	5.7

* significant at the 95% level.

The information categorization used in Table 4.7 does not differentiate between information mediums. Table 4.8 indicates provincial government extension bulletins are the most frequently consulted public information mediums, while farm supply dealers are the most frequently used private mediums. It might be noted that farm supply dealers also use the same extension bulletins available to farmers.

TABLE 4.8

Percent Frequency of Consultation of Selected Information Sources

	Primary Source	Secondary Source
MDA technical extension publ'ns	32	12
Farm Supply Dlrs.	16	21
U of M Soil Lab	15	4
Private Soil Lab	10	27
Personal Experience	6	2

4.1.2.2 Education

The distribution of farmertype by education level is presented in Table 4.9. The table indicates the survey sample is dominated by individuals with high school education. Specifically, 49 percent of the sample has a high school education. The Chi-square statistics indicate farmertypes do not differ by education in any one, or between the adoption groups. Therefore the results do not support a hypothesis that adopters are characterized by a specific type or amount of education. One possible reason for the lack of significant results includes the use of the one or more university degree(s) category of the education variable. The category includes only 16 observations, and the fact nonadopters account for 44 percent of these observations while accounting for only 34

TABLE 4.9

Percent Distribution of Farmertypes by Education

Adoption Period (No. Years Farming)	Farmer Type	Element -ary School	High School	Agri- culture Diploma	>=1 Univer- sity Degree	Per- cent	Num ber	Chi- Squ are
1970-1982	Nonadopter	14	50	17	29	100	14	
(1-13 yrs)	Late Adopter	15	55	5	15	100	34	
Group 3	Early Adopter	9	46	27	18	100	11	2.1
	Percent	14	63	15	8	100	59	
1954-1969	Nonadopter	26	52	19	3	100	27	
(14-29 yrs)	Late Adopter	14	50	29	7	100	24	
Group 2	Early Adopter	46	38	16	0	100	13	
	Innovator-2	22	67	11	0	100	9	8.5
	Percent	24	51	21	4	100	73	
pre 1954	Nonadopter	56	28	6	10	100	18	
(30+ yrs)	Late Adopter	20	60	20	0	100	5	
Group 1	Early Adopter	56	22	22	0	100	9	
	Innovator-1	11	67	11	11	100	9	13.3
	Percent	41	39	12	8	100	41	
	Percent	25	49	17	9	100	173	10.2

* significant at the 95% level.

percent of the sample is notable.

4.1.2.3 Interaction

The interaction between the development of knowledge and use of information was examined via the use of a total sample contingency table for each interaction. Appendix B reports the results of examining the use of information and Appendix C reports the analysis of education. The lack of significant results in Appendix B indicates farmers' current use of information is not related to their current knowledge levels, nor to their education. The analysis of education reported in Appendix C indicates education is not related to farmers' current awareness and knowledge of grain corn technology. However, education is related to farmers' current knowledge and use of recommended crop management practices. Table 4.10 reports the education-recommended practice contingency, and indicates the relationship is due to three dominant factors. One, a larger proportion or 32 percent of individuals scoring 1, or the lowest on the index, have an elementary school education relative to individuals scoring 2 and 3. Two, a larger proportion, or 33 percent of individuals scoring 3 have a Diploma in Agriculture relative to individual's scoring less than 3. Three, none of the farmers scoring 3 have more education than a Diploma in Agriculture.

TABLE 4.10

Percent Distribution of Score on Index Measuring Knowledge and Use of Recommended Crop Management Practices (RECOPRAC) by Operator Education

RECOPRAC Index Score	Operator Education: Elementary School	High School	Agriculture Diploma	One or More University Degrees	Per-cent	Num ber	Chi-Square
1	32	45	10	13	100	96	
2	18	52	18	12	100	56	
3	10	57	33	0	100	21	13.7*
Percent	25	9	17	10	100	173	

* significant at the 95% level.

4.1.3 Risk and Uncertainty

Table 4.11 presents the distribution of farmertypes by score on the index measuring attitude to risk and uncertainty. The lack of a significant Chi-Square indicates current attitude to risk and uncertainty is not related to farmertype nor to farming experience. Therefore the results do not support the hypothesis that adopters are less averse to risk than nonadopters, nor that risk aversity changes with age and experience. However, the results do not disprove the hypothesis because the index does not necessarily measure attitude as it may have existed when the adoption decision was made.

4.1.3.1 Farm Resources

Table 4.3 reported the distribution of farmertypes by the size of farm measured by the area under crop and summerfallow in 1983. The significant Chi-square statistics indicate farmertype is related to farm

TABLE 4.11

Percent Distribution of Farmertypes by Score on the Index Measuring Attitude to Risk and Uncertainty, RISK

Adoption Period (No. Years Farming)	Farmer Type	RISK Index Score[1] 1	2	3	Per- cent	Num ber	Chi- Square
1970-1982	Nonadopter	21	64	15	100	14	
(1-13 yrs)	Late Adopter	15	44	41	100	34	
Group 3	Early Adopter	36	36	28	100	11	5.6
	Percent	20	47	33	100	59	
1954-1969	Nonadopter	26	44	30	100	27	
(14-29 yrs)	Late Adopter	21	46	33	100	24	
Group 2	Early Adopter	23	46	31	100	13	
	Innovator-2	33	44	23	100	9	.7
	Percent	25	45	30	100	73	
pre 1954	Nonadopter	61	39	0	100	18	
(30+ yrs)	Late Adopter	20	60	20	100	5	
Group 1	Early Adopter	23	44	33	100	9	
	Innovator-1	44	39	17	100	9	10.9
	Percent	44	39	17	100	41	
	Percent	28	44	28	100	173	7.9

* significant at the 95% level.

[1] A risk score of 3 indicates the respondent was less risk averse than the respondent who scored 1.

size in each of the three adoption groups, but that size does not differ between groups. In group 3, the majority or 58 percent of nonadopters operate farms 320 acres or less in area, while 68 percent of late adopters and 53 percent of early adopters farm 640 or more acres. In group 2, 67 percent of nonadopters farm 640 or fewer acres while 56 percent or more of each of the three adopter types farm more than 640 acres. In adoption group 3, 66 percent of the innovators, and 78 percent of the early adopters farm more than 640 acres while 60 percent of the late adopters and 73 percent of the nonadopters farm less than 640 acres. In summary, the results support the hypothesis that adopters of grain corn technology operate larger area farms than nonadopters. The results do not support a hypothesis that farm size increases with operator age and experience.

Table 4.12 presents the distribution of farmertypes by the proportion of total farm capital value owed to a credit agency. The significant Chi-square in adoption group 2 indicates the use of credit is related to farmertypes with 14 to 29 years farming experience. The dominant concentrations of the relationship include 63 percent of nonadopters with no, or less than 15 percent debt, 54 and 53 percent of late and early adopters with 16 to 30 percent debt, and 44 percent of innovators with no, or less than 15 percent debt. This pattern is also evident but not significant in group 3. The notable concentrations include 36 percent of nonadopters with 0 to 15 percent debt, and 35 percent of late and 45 percent of early adopters with 51 percent or more debt. In group 1, the majority of all four farmertypes have 30 percent or less debt. In summary, Table 4.12 supports the hypothesis that adopters are larger users of credit than nonadopters. The significant Chi-square statistic in the final row of Table 4.12 also indicates the use of credit decreases with operator age and experience. Specifically, the proportion of individuals owing 15 percent or less increases from 31 percent in group 3 to 72 percent in group 1, while the proportion owing 50 percent or more simultaneously decreases from 32 to 15 percent.

TABLE 4.12

Percent Distribution of Farmertypes by the Use of Borrowed Capital

Adoption Period (No. Years Farming)	Farmer Type	Percent of Total Farm Capital Value Owed to a Credit Agency 0-15	16-30	31-50	>50	Per-cent	Num ber	Chi-Square
1970-1982	Nonadopter	36	36	14	14	100	14	
(1-13 yrs)	Late Adopter	29	18	18	35	100	34	
Group 3	Early Adopter	27	9	19	45	100	11	4.9
	Percent	31	20	17	32	100	59	
1954-1969	Nonadopter	63	7	15	15	100	27	
(14-29 yrs)	Late Adopter	21	54	21	4	100	24	
Group 2	Early Adopter	31	53	8	8	100	13	
	Innovator-2	44	22	11	22	100	9	21.3*
	Percent	41	33	15	11	100	73	
pre 1954	Nonadopter	94	0	0	6	100	18	
(30+ yrs)	Late Adopter	60	20	20	0	100	5	
Group 1	Early Adopter	45	11	11	33	100	9	
	Innovator-1	67	11	0	22	100	9	16.2
	Percent	72	7	5	15	100	41	
	Percent	45	23	13	19	100	173	29.1*

* significant at the 95% level.

4.1.3.2 Use of Crop Insurance

Table 4.13 includes the distribution of farmertype by the proportion of total crop acreage normally insured. Nonadopters in adoption group 3 are smaller users of crop insurance than adopters. Specifically, 57 percent of nonadopters do not normally insure their crops, while 61 percent of late and 73 percent of early adopters insure 76 to 100 percent of their crop. The lack of a relationship in the remaining groups is principally due to the concentration of all farmertypes in the 76 to 100 percent insured acreage category. Table 4.13 also indicates the proportion of crop normally insured is not related to farm operator age and

TABLE 4.13

Percent Distribution of Farmertypes by the Proportion of Total Crop Area Normally Insured

Adoption Period (No. Years Farming)	Farmer Type	Percent of Grain & Oilseed Acreage Normally Insured 0	1-50	51-75	76-100	Per-cent	Num ber	Chi-Square
1970-1982	Nonadopter	57	7	7	29	100	14	
(1-13 yrs)	Late Adopter	12	12	15	61	100	34	
Group 3	Early Adopter	18	9	0	73	100	11	16.5*
	Percent	24	10	10	56	100	59	
1954-1969	Nonadopter	11	3	19	67	100	27	
(14-29 yrs)	Late Adopter	17	17	12	54	100	24	
Group 2	Early Adopter	7	0	7	86	100	13	
	Innovator-2	33	0	33	33	100	9	13.6
	Percent	15	7	16	62	100	73	
pre 1954	Nonadopter	17	17	11	55	100	18	
(30+ yrs)	Late Adopter	40	0	0	60	100	5	
Group 1	Early Adopter	21	0	0	79	100	9	
	Innovator-1	22	11	11	56	100	9	5.2
	Percent	22	12	7	59	100	41	
	Percent	20	10	12	58	100	173	4.6

* significant at the 95% level.

experience.

Table 4.14 includes the distribution of farmertype by the type of crop insurance normally used, and reports results similar to those of Table 4.13. The type of crop insurance used is related to farmertype in adoption group 3. The notable concentrations include the 57 percent of nonadopters who do not normally use crop insurance, and 50 and 55 percent of late and early adopters who normally use all risk insurance. Although insurance type is not related to farmertype, all risk is also the most widely used by all farmertypes in groups 1 and 2. Summarizing, Tables 4.13 and 4.14 indicate that with the exception of nonadopters with 13 or fewer years farming experience who are the smallest users, the use of crop insurance dos not differ significantly between farmertypes, nor with operator age and experience.

4.1.3.3 Crop Production Mix

Table 4.15 reports the distribution of farmertype by the number of special crops grown in 1983. The number of special crops grown in 1983 is not significantly different between the three adoption period groups, but is significantly different between the farmertypes of group 1. The highlights include 67 percent of nonadopters who grew 1, and 56 percent of early and 60 percent of late adopters who grew 1 and 2 special crops, respectively. The majority of adopters in group 2 and 3 did not grow special crops in 1983, however these results are not significant. The results do not support the hypothesis that grain corn adopters are also adopters of other crop technologies. They do not conclusively disprove the hypothesis either because 1983 may not have been a typical crop year for all farmers.

TABLE 4.14

Percent Distribution of Farmertypes by Type of Crop Insurance Normally Used

Adoption Period (No. Years Farming)	Farmer Type	Insurance Type: None	Hail	All Risk	All Risk & Hail	Per- cent	Num ber	Chi- Square
1970-1982	Nonadopter	57	8	14	21	100	14	
(1-13 yrs)	Late Adopter	12	12	50	26	100	34	
Group 3	Early Adopter	18	18	55	9	100	11	14.1*
	Percent	24	12	42	22	100	59	
1954-1969	Nonadopter	11	30	44	15	100	27	
(14-29 yrs)	Late Adopter	17	17	41	25	100	24	
Group 2	Early Adopter	7	31	31	31	100	13	
	Innovator-2	33	11	45	11	100	9	6.5
	Percent	15	23	41	21	100	73	
pre 1954	Nonadopter	17	10	56	17	100	18	
(30+ yrs)	Late Adopter	40	0	60	0	100	5	
Group 1	Early Adopter	21	11	34	34	100	9	
	Innovator-1	22	45	33	0	100	9	13.0
	Percent	22	17	46	15	100	41	
	Percent	20	18	42	20	100	173	4.8

* significant at the 95% level.

Table 4.16 includes the distribution of adoptertypes by the proportion of total crop and summerfallow land used to produce grain corn in 1983. The majority of late adopters in each adoption group did not plant more than 25 percent of their cropland in grain corn in 1983, however the results are not significant in any one, nor between the three adoption groups. In summary, Table 4.16 does not support a hypothesis

TABLE 4.15

Percent Distribution of Farmertypes by the Number of Special Crops Grown in 1983

Adoption Period (No. Years Farming)	Farmer Type	Number of Special Crops 0	1	>=2	Per-cent	Num ber	Chi-Square
1970-1982	Nonadopter	57	43	0	100	14	
(1-13 yrs)	Late Adopter	47	21	32	100	34	
Group 3	Early Adopter	55	27	18	100	11	7.6
	Percent	51	27	22	100	59	
1954-1969	Nonadopter	37	48	15	100	27	
(14-29 yrs)	Late Adopter	50	25	25	100	24	
Group 2	Early Adopter	53	31	16	100	13	
	Innovator-2	56	44	0	100	9	5.7
	Percent	47	37	16	100	73	
pre 1954	Nonadopter	28	67	5	100	18	
(30+ yrs)	Late Adopter	20	20	60	100	5	
Group 1	Early Adopter	44	56	0	100	9	
	Innovator-1	44	44	12	100	9	14.1*
	Percent	34	54	12	100	41	
	Percent	45	38	17	100	173	7.6

* significant at the 95% level.

that farmers who have adopted for the longest period of time include a larger proportion of grain corn in their crop rotations. However, the results do not necessarily disprove such a hypothesis because the number of acres of grain corn grown in 1983 may be different than the number of acres typically grown.

TABLE 4.16

Percent Distribution of Farmertypes by Grain Corn Acres as a Proportion of Total 1983 Crop and Summerfallow Acres

Adoption Period (No. Years Farming)	Farmer Type	Percent of Total Crop and Summerfallow Area in Grain Corn <=25	26-50	>=50	Per-cent	Num ber	Chi-Square
1970-1982 (1-13 yrs)	Late Adopter	56	29	15	100	34	
	Early Adopter	36	28	36	100	11	2.6
	Percent	51	29	20	100	45	
1954-1969 (14-29 yrs) Group 2	Late Adopter	54	42	4	100	24	
	Early Adopter	46	31	23	100	13	
	Innovator-2	44	23	33	100	9	6.2
	Percent	50	35	15	100	46	
pre 1954 (30+ yrs) Group 1	Late Adopter	60	40	0	100	5	
	Early Adopter	33	44	23	100	9	
	Innovator-1	44	44	12	100	9	1.6
	Percent	43	43	14	100	23	
	Percent	49	34	17	100	114	1.7

* significant at the 95% level.

4.1.3.4 Interaction

This section reports the results of examining the interaction between the dependent variable and the independent variables of the attitude to risk and uncertainty equation of the interdisciplinary model. The interaction was estimated with the total sample. The section includes only the significant results. The contingency tables reporting insignificant results are included in Appendix D. The results are presented in the order the independent variables were included in the equation.

Table 4.17 reports score on the attitude index by the number of acres under crop and summerfallow in 1983, and indicates the variables are related. The dominant concentrations include 68 percent of individuals scoring 1 who farm 640 or fewer acres, while 60 and 69 percent of individuals scoring 2 and 3 respectively farm 640 or more acres. The results support the hypothesis that individuals who are more willing to operate under risk and uncertainty cultivate more land for crop production.

TABLE 4.17

Percent Distribution of Score on Attitude to Risk and Uncertainty Index (RISK) by Area Under Crop and Summerfallow in 1983

RISK Index Score[1]	Acres Under Crop & Summerfallow, 1983 <=320	321-640	641-1280	>1280	Percent	Number	Chi-Square
1	35	33	23	10	100	48	
2	17	23	40	20	100	77	
3	10	21	31	38	100	48	30.2*
Percent	20	26	32	22	100	173	

* significant at the 95% level.
[1] The higher the risk score the less is the respondent's aversity to risk.

The distribution of score on the attitude to risk and uncertainty index by operator age is presented in Table D.1. The insignificant Chi-square indicates the distribution does not support the hypothesis that younger operators are less averse to farming under conditions of risk and uncertainty. Attitude to risk by the proportion of total farm capital owed to a credit agency is reported in Table D.2, and indicates the two variables are not related. The result does not support the hypothesis that individuals less averse to risk and uncertainty use more credit. Attitude to risk and uncertainty is not related to the amount or type of crop insurance normally used, and is reported in Tables D.3. The hypothesis that less risk averse individuals use less crop insurance

TABLE 4.18

Percent Distribution by Score on Attitude to Risk and Undertainty Index, (RISK) by Number of Special Crops Grown in 1983

RISK Index Score[1]	Number of Special Crops Grown in 1983 0	1	>=2	Per-cent	Num ber	Chi-Square
1	44	51	4	100	48	
2	48	31	21	100	77	
3	42	33	25	100	48	12.0*
Percent	45	38	17	100	173	

* significant at the 95% level.
[1] The higher the risk score the less is the respondent's aversity to risk.

is not supported by these tables.

Table 4.18 reports attitude by the number of special crops grown in 1983, and indicates the variables are significantly related. Specifically, the number of crops grown gradually increases with score on the index. Similarly, Table 4.19 includes attitude by the proportion of farm area in grain corn in 1983, and indicates the variables are related. The proportion growing 25 percent or less gradually decreases, and the proportion growing 25 to 50 percent grain corn gradually increases as score on the index increases. Summarizing, Tables 4.18 and 4.19 support the hypothesis that less risk averse individuals include a greater

TABLE 4.19

Percent Distribution by Score on Attitude to Risk and Uncertainty Index, (RISK) by Grain Corn Acres as a Proportion of Total Crop and Summerfallow Acres, (1983)

RISK Index Score[1]	Percent of Total Crop and Summerfallow Acres in Grain Corn, 1983 <=25	26-50	>50	Per- cent	Num ber	Chi- Square
1	62	22	16	100	37	
2	44	37	19	100	52	
3	42	33	25	100	25	28.4*
Percent	56	38	20	100	114	

* significant at the 95% level.
[1] The higher the risk score the less is the respondent's aversity to risk.

number and a larger area of special crops in their crop rotations.

4.1.4 Congruence

Table 4.20 presents the distribution of adopter types by the congruence variable, CONG, which measures whether the survey respondent grew silage before grain corn. The Chi-square statistics indicate significantly more early adopters and innovators than late adopters with 14 to 29 years farming experience grew silage corn first. Specifically, 45 percent of early adopters and 33 percent of innovators grew silage corn compared to 9 percent of late adopters. This result must be interpreted with respect to two further observations. Firstly, preliminary analysis of the data indicated the majority of silage growers also operated livestock entreprises in 1983. Secondly, adoption group 2 includes farmers who did and were eligible to adopt grain corn between 1954 and 1969 when total provincial acreage was less than the previous and subsequent adoption periods. The post 1953 acreage decline suggests grain corn production technology was perhaps not as well developed as it appeared to be before 1954. Therefore, Table 4.20 suggests experimentation with congruent, or silage corn production technology was important in acquiring knowledge of grain corn production techniques during the period when

TABLE 4.20

Percent Distribution of Adoptertypes by Experience Growing Silage Before Grain Corn, CONG

Adoption Period (No. Years Farming)	Farmer Type	Grew Silage Before Grain Corn		Per-cent	Num ber	Chi-Square
		NO	YES			
1970-1982	Late Adopter	82	18	100	34	
(1-13 yrs)	Early Adopter	73	27	100	11	.40
	Percent	80	20	100	45	
1954-1969	Late Adopter	91	8	100	24	
(14-29 yrs)	Early Adopter	55	45	100	13	
Group 2	Innovator-2	67	33	100	9	11.2*
	Percent	76	24	100	46	
pre 1954	Late Adopter	40	60	100	5	
(30+ yrs)	Early Adopter	55	45	100	9	
Group 1	Innovator-1	89	11	100	9	4.10
	Percent	65	35	100	23	
	Percent	75	25	100	114	1.90

* significant at the 95% level.

grain corn technology suited to the province was being developed.

4.2 THE ECONOMIC MODEL

The economic model was estimated from a cross-section of annual observations from the four survey subregions for the years 1970 to 1982, and is reported in Table 4.21. Table 4.21 indicates the stocks of grain on farms variable, SOF is the only significant variable in the model which explains 67 percent of the variability in the dependent variable. The large standard errors of the profitability, PROFIT and the technology, HYBRID variables suggest the variables are collinear. Multicollinearity can lead to large standard errors and therefore a lack of reliability in the estimated coefficients of a linear model (Koutsoyannis, 1977). A Farrar-Glauber test for multicollinearity indicates the profitability and technology variables are correlated. Specifically, Table 4.21 also reports the partial correlation coefficients of the explanatory variables and the sole significant t-statistic indicates the PROFIT-HYBRID variables are negatively related.

The interdisciplinary model addresses adoption that occurred after as well as prior to 1970, yet the economic model was estimated for 1970 to 1982 only. The 1970 to 1982 period was selected for two reasons. One, data measuring economic conditions prior to 1970 were not consistently available. Two, grain corn production experienced its largest increase during this period, therefore the period is of principal interest. To recall, two distinct adoption phases can be identified between 1970 and 1982, namely 1970 to 1977 as acreage gradually increased and 1978 to 1982 as acreage dramatically increased. A Chow test (Koutsoyannis,

TABLE 4.21

Estimation of the Economic Model, 1970-1982

(6) $$CORNSHARE = \underset{(.04)}{-.09^*} - \underset{(.008)}{.014PROFIT} + \underset{(.0001)}{.0001HYBRID} + \underset{(.001)}{.006TOTSOF^*} + .05RATIO^* \qquad R^2 = .6732$$

( ) numbers in parentheses are standard errors

Partial Correlation Matrix

	PROFIT	TOTSOF
TOTSOF	.02 (.13)	
HYBRID	-.42* (3.6)	.001 (.007)

( ) numbers in parentheses are t-statistics

*significant at the 95% level

1977) of the economic model was conducted to determine whether the economic conditions that prevailed between 1970 and 1977 were different from those that existed after 1977. The Chow test uses the F statistic to estimate whether the sum of squared residuals, SSR of a model estimated from two or more subsamples is significantly different from the SSR of the same equation estimated from the total sample, as per equation 7.

(7) $$F = \frac{(SSR_t - (SSR_1 + SSR_2))/k}{(SSR_1 + SSR_2)/(n_1 + n_2 - 2k)}$$

where:

SSR_t : Total sample 1970-82

$SSR_1(n_1)$: subsample 1970-77

$SSR_2(n_2)$: subsample 1978-82

k: number of explanatory variables

Equation 7 yields an F statistic of 10.3 which is significant at the 95 percent level, and therefore indicates the 1970 to 1977 economics of grain corn production were different from those of the period 1978 to 1982. Table 4.22 reports the results of estimating the economic model after accounting for structural change. Equation 8.1 was estimated for the period 1970 to 1977, while equation 8.2 measures the period 1978 to 1982. The relatively smaller R^2 of .78 and lack of significant explanatory variables in equation 8.1 indicate the economic conditions measured by the model do not explain the variability in grain corn acreage between 1970 and 1977. Conversely, all of the explanatory variables of equation 8.2 are significant, and the model explains 94 percent of the variation in the dependent variable. Furthermore, the significant t-statistics of the three explanatory variable coefficients of equation 8.2 indicate the large standard errors of the estimated coefficients and therefore the problems of multicollinearity encountered in equation 7 are reduced.

TABLE 4.22

Structural Change in the Economics of Grain Corn Adoption, 1970-77, 1978-82

(8.1) $CORNSHARE = \underset{(.86)}{.02} - \underset{(-.81)}{.002PROFIT} - \underset{(-.35)}{.0003HYBRID} - \underset{(-1.79)}{.0007TOTSOF}$

$+\underset{(5.04)}{.02D2*}$ $R^2 = .78$ DF = 16 1970-1977

(8.2) $CORNSHARE = \underset{(-2.13)}{-.24*} + \underset{(2.21)}{.07PROFIT*} + \underset{(2.87)}{.01HYBRID*} + \underset{(3.01)}{.0006TOTSOF*}$

$+ \underset{(2.5)}{.06D2*} + \underset{(3.98)}{.09D3*}$ $R^2 = .94$ DF = 11 1978-82

( ) numbers in parentheses are t-statistics
* significant at the 95% level

Table 4.22 indicates all three independent variables of the economic model are significant in explaining the variability in total cultivatable acres planted to grain corn in the survey region between 1977 and 1982. Specifically, the combination of a 7 percent change in the profitability of grain corn relative to conventional cereal production, a 1 percent increase in the number of grain corn hybrids available, and a .6 percent increase in the stocks of grain on Manitoban farms, (measured in million bushels) caused a 1 percent annual increase in the proportion of cultivatable survey region land planted to grain corn. These results support the hypotheses that profitability, the availability of hybrid seed, and the opportunity foregone on grain stocks were important in bringing about adoption after 1977. The negative and significant intercept identifies the short term irreversibility of grain corn production. More precisely, the amount of capital required, and the use of residual herbicides to produce grain corn is such that acreage is not decreased as quickly as it is increased. The size of the investment required is such that under short term unprofitable conditions farmers may continue to use the equipment to produce corn and minimize their losses relative to liquidating the equipment at possibly reduced prices. Similarly, land treated with a corn herbicide that remains as a soil residue will frequently not produce crops other than, and therefore must be used to produce corn in subsequent crop years.

4.2.1 Spatial Considerations

The economic model included three variables RATIO2, RATIO3 and RATIO4 specified to measure whether the profitability of corn relative to wheat production was different in explaining the variability in the growth of grain corn acreage in subregions 2, 3 or 4 relative to subregion 1. None of the three variables are significant thereby indicating the effect of profitability on adoption was not significantly different between the respective subregions. The model also included three dummy variables D2, D3 and D4 designed to measure whether there were factors influencing the growth of grain corn acreage in subregions 2, 3 and 4 respectively that were not present in subregion 1. Table 4.22 indicates variable D2 is significant in equation 8.1, and variables D2 and D3 are significant in equation 8.2. These results suggest there are factors other than those included in the model that are significant in explaining the growth of grain corn in subregions 2 and 3 relative to subregion 1.

The use of information by all farmertypes within a survey subregion was compared between all four subregions. The distribution indicated the type of information sources consulted by farmers with different amounts of farming experience is not related to farmer's location, and therefore is not reported in order to reduce the volume of tabular presentations to a manageable level. If farmers' current is reflective of past information use, then the analysis of subregional information use indicates the pattern grain corn adoption followed in the survey region was not determined by the type of information used.

The distribution of farmers' awareness and knowledge of grain corn technology, and knowledge and use of recommended crop management practices was also examined between survey subregions for each of the three adoption period groups of the interdisciplinary model. Similar to their use of information, farmers' current knowledge as measured by the three indices was not significantly different between subregions. Given the insignificance of the results of examining subregional knowledge, and the desire to minimize the number of tabular representations the results are not included.

4.3 SUMMARY AND DISCUSSION

This chapter reported the results of estimating the interdisciplinary and economic analytical models employed by the study. The interdisciplinary model was used to identify the significant socioeconomic, psychological, and use of information characteristics of a survey sample of farmers, while the economic model was used to identify the economic conditions under which adoption occurred in the survey region. The interdisciplinary model identififed four farmertypes involved in the grain corn adoption process. This section summarizes and interprets the significant characteristics of each farmertype, as well as the results of the economic model.

The first item to note is the size and representativeness of, and the nature of the data included in the survey sample. The grain corn adopter sample includes 25 percent of the 1981 population of grain corn growers in the survey region. The adopter sample primarily includes disproportionately more early and late adopters in the 35 to 49 year old, and 1600 to 2879 acre farm size ranges than is found in the population. The nonadopter sample includes 3 percent of the 1981 population of nonadopters in the survey region. The sample contains disproportionately more 35 to 39 year, and fewer 15 to 29, and 60 to 69 year old farmers and 1120 to 1599 acre farms than is found in the population. Both adopter and nonadopter samples include data measuring the characteristics of farmers as they existed in 1983 when the survey was conducted. In total, while the adopter sample is relatively larger than the nonadopter sample, the size of each suggests neither sample necessarily reflects the variation that may exist in its respective population. Nonetheless, it was not possible to determine the exact representativeness of the survey sample, therefore the analytical results are interpreted as general features of the population.

The interdisciplinary model divided the sample into three adoption groups. Each group included three to four farmertypes. The number of years of farming experience all farmertypes within a group have increases from 1 to 13 years in group 3, 14 to 29 years in group 2, and 30 or more years in group 1. The distribution of farmertypes by age within a group also increases from less than 29 to over 40 years in group 3, to less than 29 to over 50 years in group 2, and from 40 to over 60 years in group 1. Therefore, since the grouping was used to examine change in farmer characteristics over time, the method also examined how characteristics change with farm operator age.

Farmertypes with 30 or more years farming experience, who were assumed eligible to adopt the first hybrid grain corn seed imported from the U.S., differ significantly in age. Sixty-seven percent of farmers who innovated before 1954 are 60 or more years of age, while 61 percent of nonadopters and 100 percent of late adopters are between 50 and 59 years. These results suggest farmer age was a factor during the grain corn innovation period. The majority, or 67 percent of the adopter sample, compared to 29 percent of the nonadopter sample operate farms over 320 acres in area. Although the adopter sample overrepresents large farms, specifically 1120 to 1599 acre farms, this result indicates grain corn adopters tend to be larger crop farmers than nonadopters.

Farmertypes also differ significantly in their knowledge of recommended crop production practices, and use of information. Eighty-five percent of the nonadopting compared to 20 percent of the adopting sample scored 1, or the lowest possible score on the index measuring awareness of grain corn production techniques. All farmertypes' score on the index measuring knowledge and use of recommended crop management practices increases with years of farming experience and operator age and education. Seventy-three percent of early adopters with 13 or fewer years farming experience use public sources of information more frequently relative to 56 percent of late adopters and 57 percent of nonadopters with an equivalent amount of farming experience who use private information sources more frequently. Lastly and relatedly, 45 percent of early adopters and 33 percent of innovators compared to 9 percent of late adopters with 14 to 29 years farming experience grew silage before grain corn. In total, this evidence indicates nonadopters are less aware of grain corn technology than are adopters, that application of recommended crop management practices increases with farming experience, and operator age and education, and that the public sector was important in dispersing crop production information after the innovation period. The use of congruent technology also was important in acquiring knowledge of grain corn production techniques after the innovation period.

The three adopter farmertypes identified by the analysis do not differ between themselves, nor from nonadopters in their present atttitude to risk and uncertainty as measured by the index employed by the analysis. However, the index indicates risk aversity decreases with farm size, the proportion of grain corn to total 1983 crop acreage, and the number of special crops grown in 1983. These three factors measure current conditions. Therefore since each factor's significant relationship with attitude to risk and uncertainty supports the hypothetical framework, it can be concluded the risk index is measuring current attitude. Since attitude could have changed over time, the lack of a significant difference between different farmertypes' current attitude does not conclusively indicate attitude was not a factor in adoption prior to the date of the survey.

The analysis identified two other indicators of attitude whose significance must be interpreted with respect to the size and representativeness of the survey sample. Firstly, 57 percent of the nonadopters in adoption group 3, or those with 13 or fewer years farming experience do not normally use crop insurance. The nonadopting sample's underrepresentation of the under 29 year, and overrepresentation of the 35 to 39 year age groups is evident in adoption group 3, therefore this result does not necessarily reflect the least experienced-nonadopting population's use of crop insurance. However, this same sample of nonadopters farmed insignificantly fewer total crop acres and grew insignificantly fewer special crops in 1983 than the remaining farmertypes. These results suggest younger, less experienced nonadopters do not use crop insurance because they grow fewer crops whose yield is less uncertain than the crops grown by all other farmertypes. The second indicator includes 72 percent of nonadopters and 80 percent of late adopters with 30 or more years farming experience who grew 1 or more special crops in 1983, compared to 56 percent of early adopters and 56 percent of innovators with equivalent farming experience. The late adopting sample underrepresents the number of 50 to 59 year olds, while the nonadopting sample underrepresents the number of 60 to 69 year olds in their respective populations, therefore special crop production by the sample does not necessarily reflect that of the population. Nonetheless, the results suggest non and late adopters who were eligible to may not have innovated with grain corn because they adopted other special crops.

Farmertypes of adoption group 2, or those with 14 to 29 years farming experience differ in their use of borrowed capital. Seventy-nine percent of late and 69 percent of early adopters owe more than 15 percent of the total capital value of their farm to a credit agency. This is compared to 37 percent of the nonadopters and 55 percent of the innovators of group 2 who owe more than 15 percent of the value of their farms. The adopting sample's overrepresentation of 35 to 49 year old early and late adopters is evident in group 2, and may account for the significant difference in the use of borrowed capital between farmertypes.

The use of borrowed capital also decreases with operator age and farming experience. The dominant features of this relationship include 32 percent of all farmertypes with less than 14 years experience who owe 50 percent or more of the total value of their farm to a credit agency, compared to 11 and 15 percent of all farmertypes with 14 to 29, and more than 30 years farming experience respectively. Thirty-three percent of all farmertypes with 14 to 29 years experience owe 16 to 30 percent of total farm value relative to 20 and 7 percent of farmerytpes with less than 14, and more than 30 years experience respectively. Seventy-two percent of all farmertypes with 30 or more years farming experience owe less than 16 percent of the total capital value of their farms compared to 31 and 41 percent of farmertypes with less than 14, and 14 to 29 years experience respectively. Early and late adopters account for the predominant concentrations in the less than 14, and 14 to 29 years farming experience groups, while nonadopters account for the dominant concentration in the over 29 years experience group. In total, the results indicate early and late adopters are currently the largest users of borrowed capital, and that the use of borrowed capital tends to decrease with years spent farming and age. The results do not necessarily measure the use of borrowed capital at the time farmers made their respective adoption decisions. However, insofar as current debt structure reflects previous borrowing action, the results suggest adopters use more borrowed capital than nonadopters.

The results of the economic model indicate the profitability of grain corn production was an important factor during the most notable period of grain corn expansion within the survey region. More precisely, the results indicated the per acre expected profitability of grain corn relative to conventional crop production and the opportunity cost of holding stocks of conventional grains on farms prompted farmers to adopt grain corn after 1977, as opposed to prior to 1977. The model also indicated the availability of hybrid corn seed technology was important in the adoption of grain corn after 1977. Specifically, as the number and variety of hybrids increased, so did the number of grain corn acres.

Chapter V

SUMMARY AND CONCLUSIONS

This chapter includes a summary of the analysis undertaken and a suggestion for future research.

5.1 SUMMARY

Technology is an important component of modern agricultural production. The use of technology can decrease the costs of, and/or increase the output from agricultural production. Technology is therefore often seen as a means of improving the incomes of Canadian farmers who must remain competitive in national and international food markets. Recent advances in, and application of biotechnology hold particular promise for agricultural crop production. Since the public sector has historically been involved in the transfer and development of farming technology, this study analyzed the transfer and adoption of agricultural crop technology to gain insights as to how such technology can be effectively transferred in the future.

A case study approach was taken. Specifically, the production of grain corn in Manitoba increased significantly since 1970. Therefore it was assumed an examination of grain corn adopters and their use of the transfer system would provide the desired insights. The study sought to determine the socioeconomic and psychological characteristics of the farmers involved in the use of grain corn technology, their use of crop production information, and the economic environment under which grain corn was adopted. A mail survey of farmers in the southcentral region of Manitoba where grain corn was first produced was conducted to obtain data for the analysis. An interidsciplinary model was developed to analyze the primary survey data, while an economic model was used to examine secondary data.

The adoption of an agricultural crop technology was conceptualized as a temporal process involving related changes in the technical development and farmers' assessment of a technology. In turn, the interaction of a farmer's mental capacity, situation, and value system over time was hypothesized to determine if, as well as when the individual adopts a technology. The interdisciplinary model was developed to test this conceptualization on the basis of the survey data. Since the static survey data included observations on farmers' characteristics as they existed at one point in time, the interdisciplinary model split the data into three groups in an attempt to examine intertemporal change. The grouping was consistent with the development of Manitoba hybrid corn seed technology. Specifically, prior to 1950 hybrid seed from the U.S. was the principal type of grain corn seed available in Manitoba. In 1950 the Morden Research Station introduced two hybrids suited to the province and acreage dramatically increased only to decrease an equivalent amount four years later in 1954. Acreage remained relatively constant between 1955 and 1970. In 1970 acreage again began to increase as a greater number and variety of hybrids became available. Farmers who adopted and farmers who were farming at the time and therefore eligible to adopt before 1954 were included in the first group of the model. Farmers who did and farmers who were eligible to adopt between 1954 and

1969 were included in the second group, while farmers who adopted and who were eligible to adopt after 1969 were included in the third group of the model. Within each group farmers were further identitifed by the period in which they adopted grain corn. Farmers who adopted before 1954 were identified as innovator-1 farmertypes. Those who adopted between 1954 and 1969 were termed innovator-2s, while those who adopted between 1970 and 1977 were labelled early adopters, and those who adopted after 1977 were identified as late adopters. The model statistically examined the distribution of farmertypes by characteristic within and between each of the three groups as a test of the working hypothesis.

The survey sample did not equally represent all farm operator age and farm size groups found in the population. Specifically, the sample of grain corn adopters represented 25 percent of, and included disproportionately more 35 to 49 year old early and late adopters and 1120 to 1599 acre farms than the 1981 Census population of grain corn growers in the region. The nonadopter sample included only 3 percent of the 1981 population of nonadopters in the region, and represented disproportionately more 35 to 39 year olds, and fewer 15 to 29 and 60 to 69 year olds, as well as fewer 1120 to 1599 acre farms. An attempt was made to identify the bias in all of the analysis undertaken, however exact identification was not always possible. Therefore, although the sample did not necessarily represent the variation of the population, the analytical results were interpreted as general features of the population.

The analysis identified differences in operator age and farm size between farmertypes that can be associated with adoption action. Innovators were older than non and late adopters who were eligible to adopt grain corn during the same period, thereby suggesting farmer age is a factor during the innovation period. Specifically, 67 percent of the innovators who adopted before 1954 were 60 years or older in 1983 compared to 61 percent of the non and 100 percent of the late adopters who were farming in 1954 but who were between 50 and 59 years of age in 1983. All adopters tend to be larger crop farmers than nonadopters. Sixty seven percent of all adopters grew more than 320 acres of crop in 1983 compared to 29 percent of all nonadopters.

Farmers' use of information was examined with the use of one index measuring the type of information sources consulted, and three indices measuring different types of knowledge. Nonadopters were identified as being less aware of grain corn technology than were adopters, however nonadopters were not so unaware as to be ignorant of grain corn production techniques. Farmertypes did not differ in their knowledge of recommended grain corn production techniques nor in their knowledge and use of generally recommended crop management practices, however knowledge and use of generally recommended practices was found to increase with operator age, experience, and education. Specifically, 61 percent of the least experienced group scored 1, or the lowest on the index measuring knowledge of recommended practices compared to 56 percent of the second most, and 46 percent of the most experienced group. Similarly, 7 percent of the least experienced group scored 3, or the highest on the index compared to 10 and 25 percent of the second and the most experienced groups respectively. As for education, notable results include 32 percent of individuals with a maximum of elementary education, and 45 percent of individuals with a maximum of high school education who scored 1 on the generally recommended practice index compared to 10 percent of Agriculture Diploma graduates. The proportion of Diploma graduates increased with score on the index from 10 percent who scored 1 to 33 percent who scored 3.

Farmertypes also differed in their use of information in making crop production decisions. The analysis indicated younger farmers including those who did not adopt and those who recently adopted grain corn make more frequent use of private information sources than older farmers. Older farmers include non and early adopters and innovators who tend to use publicly supplied information most frequently. For example, 57 percent of the non and 56 percent of the late adopters with 13 or fewer years farming experience use private information sources most frequently compared to 73 percent of early adopters with an equivalent amount of experience who use public information most frequently. In a related vein, the use of congruent or silage corn production technology was observed to be important in acquiring knowledge of grain corn production techniques immediately after the innovation period. Specifically, 45 percent of early adopters and 33 percent of innovators with 14 to 29 years farming experience grew silage before grain corn relative to 9 percent of late adopters with comparable experience.

In total, the analysis of information use segment of the study indicated the movement of information has been adequate so nonadoption is not the result of ignorance. The analysis also indicated that although older, more experienced farmers who were among the first to adopt grain corn tend to rely on public information more frequently than younger, less experienced farmers who adopted later and who tend to rely on private information more frequently, the difference in the type of information used is not related to farmers' awareness and knowledge. The identified difference in information use suggested the public sector was important in diffusing technological information after the innovation, and before the late adoption period wherein the technology was adopted on a broader basis. The use of congruent silage corn production technology in learning grain corn production techniques was also observed to be important during this period. Finally, the analysis indicated age, experience, and education, especially a Diploma in Agriculture, are important determinants of farmers' application of generally recommended crop management practices.

An index designed to measure farmer attitudes to risk and uncertainty was employed by the study. Analysis of the index indicated attitude does not differ significantly between farmertypes, nor does attitude change with age and experience. Further analysis confirmed the index was measuring a dimension(s) of attitude to risk and uncertainty, although the dimension(s) may not have included attitude as it applies to the adoption of new technology. Specifically, score on the attitude index was positively related to the number of acres under crop and summerfallow, the proportion of grain corn to total crop and summerfallow acres, and the number of special crops grown in 1983. These results indicate relatively less risk averse farmers grow a larger area and a greater variety of crops, including special crops such as grain corn.

The analysis provided some evidence that adopters are larger users of borrowed capital than are nonadopters. Specifically, 37 percent of the nonadopters with 14 to 29 years farming experience owe 15 percent or less of the total capital value of their farm to a credit agency versus 79 percent of late adopters, 69 percent of early adopters, and 55 percent of innovators. The analysis also indicated the use of borrowed capital changes with farm operator age and experience as was hypothesized. For example, 31 percent of all farmers with 13 or fewer years farming experience owed 15 percent or less of the total capital value of their farm to a credit agency compared to 41 percent of farmers with 14 to 29 years, and 72 percent of all farmers with 30 or more years experience.

Finally, the analysis supported previous research that found profitability was an important determinant of adoption. The economic model estimated the significance of the dollar per acre profitability of grain corn relative to wheat production, the availability of hybrid seed technology, and the opportunity foregone on unsold grain stocks held on farms in explaining grain corn's share of total crop and summerfallow acreage in the survey region for the years 1970 to 1982. The model identified a structural change between the periods 1970 to 1977 and 1978 to 1982. Each of the three variables of the model was significant during the 1978 to 1982 period, while all were insignificant for the 1970 to 1977 period. Since grain corn acreage experienced its most dramatic increase between 1978 and 1982, the results of the model confirmed the importance of profitability in bringing about adoption. The model also indicated factors other than the three aforementioned variables were important in explaining the growth of grain corn in survey subregions 2 and 3 relative to subregion 1, where the adoption of grain corn originated. However, comparison of farmers' knowledge and use of information suggested these variables did not account for the difference between subregions.

5.2 SUGGESTION FOR FUTURE RESEARCH

Three items are noteworthy. One concerns the survey method used. While the 36 percent average response rate obtained by the mailout survey is not particularly representative, the mail out method is of some value. It might be used as the initial instrument in a survey that maintains records of individual responses. The mail survey could then be followed with personal forms of contact. Such a study would obviously require more resources. Two, the method of examining the use of information through knowledge indices appears to have some merit. However, subsequent surveys should differentiate between general and technical knowledge. The movement of ideas, as opposed to technical, applied information might be identified in this manner. Third, since grain corn adopters tend to be adopters of technology in general, subsequent research might not use a case study approach. Rather, future research might simultaneously examine a producer's use of a variety of technological developments.

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Appendix A

SURVEY FORM (VERSION 1)

The survey response results are also included. The figures given are percentages and averages for the entire sample before accounting for incomplete responses.

* PLEASE ANSWER THE FOLLOWING BY PLACING A CHECKMARK IN THE APPROPRIATE BLANK.

1. Do you, or have you ever grown grain corn?___71%___YES___29%___NO
   If NO, please go to question 5.
   If YES, in what year did you first grow grain corn?____Ave=1975____

2. Do you still grow grain corn?__98.7%__YES___1.3%__NO
   If YES, how many acres did you grow in 1983?___Average=325___acres.

3. Did you grow silage corn before grain corn?___61%___YES___39%___NO
   If YES, approximately in what year did you first grow silage corn?
   ____Average=1962_______

4. Are you a member of the Manitoba Corn Growers Association?
   __91.4%__YES__8.6%___NO.

5. Do you currently raise livestock?___51%___YES___49%___NO.
   If NO, please go to question 6. If YES, please check any of the following that accurately describe your livestock operation(s).

10%	_____hogs, weanlings only
16	_____hogs, market weight animals
10	_____dairy
52	_____beef
6	_____chickens, layers
5	_____chickens, broilers
0	_____turkeys
1	_____other, please specify___Geese________

6. Was your decision to begin growing grain corn related to your livestock operation? (For example, did you decide to change the amount, or type of livestock you produce?)____5%___YES___95%___NO
   If NO, please go to question 7. If YES, please check and fill in the information required as it applies to you.

9%	_____I stopped raising_____Livestock__________________.
0	_____I began raising __________________________.
9	_____I decreased my production of___Livestock_____________.
64	_____I increased my production of___Livestock_____________.
18	_____other, please specify___Marketing_Considerations_______

7. What hybrid corn seed did you use in 1983? Please give the brand and variety name as well as the number of acres of each hybrid grown in 1983.

NAME		ACRES	
Used_8_varieties	2.4%	Used_4_varieties	29.9%
" 7 "	.8	" 3 "	21.3
" 6 "	6.3	" 2 "	15.7
" 5	15.7	" 1 "	7.9

8. At what rate, in plants/acre, did you seed your grain corn last year? Please check the most appropriate answer.

0.0%	___less than 18000 plants/acre
3.7	___18-20000 plants/acre
27.1	___20-22000 "
42.1	___22-24000 "
5.1	___more than 24000
22.0	NO ANSWER

9. How far apart were your grain corn rows spaced last year? Please check the closest answer.

15.0%	___30 in.
0.0	___32 in.
0.0	___34 in.
77.2	___36 in.
7.8	___38 in.
0.0	___40 in.

10. How far apart within a row did you space your grain corn plants last year? Check the most appropriate answer.

3.2%	___5 in.
27.6	___6 in.
43.3	___7 in.
22.0	___8 in.
3.9	___9 in. or more

11. How deep did you plant your grain corn last year? Please check the most appropriate answer.

7.9%	___1 in.
73.2	___2 in.
16.5	___3 in.
2.4	___4 in.
0.0	___5 in.

12. About how much precipitation must you receive during an average growing season of May 1 to September 30 in order to obtain a grain corn yield of 80 bu./acre, or better? Check the most appropriate answer.

23.8%	NO ANSWER
1.9	___20-22 in.
8.9	___18-20 in.
18.2	___16-18 in.
25.2	___14-16 in.
21.5	___12-14 in.
.5	LESS

13. About how much precipitation must you receive during an average growing season of May 1 to September 30 in order to obtain a wheat yield of 30 bu./acre, or better? Check the most appropriate answer.

9.8%	NO ANSWER
3.3	____20-22 in.
4.2	____18-20 in.
11.7	____16-18 in.
22.0	____14-16 in.
48.1	____12-14 in.
.9	LESS

14. About how much precipitation do you receive during an average growing season of May 1 to September 30? Check the most appropriate answer.

14.5%	NO ANSWER
3.3	____20-22 in.
2.8	____18-20 in.
15.9	____16-18 in.
24.3	____14-16 in.
34.6	____12-14 in.
4.6	LESS

15. By what date in the spring , assuming that the weather is favorable, do you like to have your grain corn planted? __Average=May __15_
mo. day

16. What is the latest date you will plant grain corn?_Average=May __28_
mo. day

17. How often do you soil test? Check the most appropriate answer.

12.2%	NO ANSWER
29.0	___never
22.0	___every year
15.9	___every 2 years
19.6	___every 3 years
1.3	___every 4 or more years

18. Choose one of the following popular corn herbicides that is the least likely to remain as a residue in the soil from year to year. Please check one.

7.0%	NO ANSWER
0.0	___Atrazine, or an Atrazine solution
10.8	___Ekko
12.1	___Primextra
70.1	___Eradicane

19. Choose one of the following popular herbicides that will control wild oats and foxtail in wheat. Please check one.

28.5%	NO ANSWER
0.0	____Avadex BW
2.8	____Treflan
.5	____Wypout
68.2	____Hoe Grass
0.0	____Stampede CM

20. Do you grow grain corn in rotation with other crops?4____46.3%___YES
__36.4%__NO__17.3%__NO ANSWER
If NO, please go to question 21. If YES, please list the crops that you grow in the order that you normally include them in a rotation with grain corn.

____cereal____________97%____
____flax______________28%____
____peas______________18%____
____

21. Which one of the following is the most nutrient conserving method of applying nitrogen fertilizer? Please check only one answer.

2.8% NO ANSWER
7.1 ___spring broadcasting
4.6 ___fall broadcasting
73.4 ___spring banding
12.1 ___fall banding

22. Which one of the following methods do you normally use to calibrate your field sprayer? Please check your answer.

16.4% NO ANSWER
27.6 ____I do not normally calibrate my sprayer.
25.7 ____spray out a measured volume of water and herbicide at a set speed and pressure, and divide the volume by the area of cropland covered.
22.4 ____spray a measured volume of water over a measured distance at a set speed and pressure.
7.4 ____spray a measured volume of water over a measured area of land at a set speed and pressure.
.5 ____I hire a custom applicator to do all my spraying.

23. How often do you have the plant tissue of your crops analyzed by a professional? Please check the most appropriate answer.

5.2% NO ANSWER
77.6 ____never
5.6 ____every year
3.7 ____every 2 years
6.5 ____every 3 years
1.4 ____every 4 or more years

24. Assuming favorable weather conditions, at what percentage kernel moisture do you prefer to start harvesting your grain corn? Check the most appropriate answer.

19.6% NO ANSWER
1.9 ___30-35% moisture
50.9 ___25-29%
25.7 ___20-24%
1.4 ___16-19%
.5 ___14-16%

25. At what temperature should you dry grain corn for feed? for distillery use? Please check the most appropriate answer under each category.

	FEED		DISTILLERY
41.6%	___190 F (90 C)	0.0%	___190 F (90 C)
33.6	___165 F (75 C)	13.6	___165 F (75 C)
.5	___140 F (60 C)	37.9	___140 F (60 C)
0.0	___115 F (45 C)	0.0	___115 F (45 C)
0.0	___90 F (30 C)	0.0	___90 F (30 C)
1.4	CUSTOM DRIED	1.4	CUSTOM DRIED
22.9	NO ANSWER	47.1	NO ANSWER

26. Do you routinely burn the straw off any of your land in the fall?
__97.2%__YES___1.4%__NO ___1.4%__NO ANSWER

27. Do you use a straw chopper on your combine?__93.5%__YES___1.4%__NO
___5.1%__NO ANSWER

* QUESTIONS 28 TO 30 ASK YOU ABOUT SOME OF THE SOURCES OF INFORMATION THAT YOU MIGHT USE. PLEASE ANSWER THESE QUESTIONS BY RANKING THE 3 SOURCES THAT YOU CONSIDER TO BE THE MOST IMPORTANT IN HELPING YOU MAKE THE DECISION INDICATED. GIVE A RANK OF 1 TO THE SOURCE THAT YOU CONSIDER THE MOST IMPORTANT, A 2 TO THE SECOND MOST IMPORTANT, AND A 3 TO THE THIRD MOST IMPORTANT.

28. Here is a list of sources that you may consult for fertilizer inforion. Please rank the 3 sources that you consider to be the most important in helping you make your fertilizer decisions.

1st	2nd	3rd	RANK
3.5%	11.8%	13.2%	____ag rep
21.1	24.6	24.7	____fertilizer dealer
44.7	13.4	9.3	____soil test lab, University of Manitoba
12.1	12.3	8.2	____other soil test lab
5.0	13.4	19.8	____Manitoba Corn Growers Association corn school
4.0	19.3	15.4	____other farmers
.5	4.3	2.2	____university
7.5	1.1	6.6	____other, please specify____experience__________
1.5	0.0	.5	_____public_press____________________________

29. Here is a list of sources that you may consult for herbicide inforion. Please rank the 3 sources that you consider to be the most important in helping you make your herbicide decisions.

1st	2nd	3rd	RANK
4.1%	8.4%	11.7%	____chemical company salesperson
21.8	32.1	19.7	____fertilizer and farm supply dealer
55.8	17.9	12.8	____Guide to Chemical Weed Control by Manitoba Agriculture
3.6	11.1	6.9	____ag rep
5.1	14.2	23.9	____Manitoba Corn Growers Association corn school
5.6	13.7	19.1	____other farmers
2.0	1.1	3.2	____university
2.0	1.6	2.6	____other, please specify,____experience___________

30. Here is a list of sources that you may consult for seed information. Please rank the 3 sources that you consider to be the most important in helping you make your seed decisions.

1st	2nd	3rd	RANK
10.7%	13.2%	30.3%	____seed company salesperson
3.6	5.8	9.0	____fertilizer and farm supply dealer
41.3	18.5	11.7	____Field Crop Recommendations by Manitoba Agriculture
2.0	12.7	9.0	____ag rep
17.9	24.3	18.1	____Manitoba Corn Growers Association corn school
14.3	22.2	14.9	____other farmers
.5	.5	3.2	____university
9.7	2.6	3.7	____other, please specify_____experience_________

31. Here is a list of marketing agents that you might sell your grain to. Please rank this list according to the amount of grain that you have sold to each agent over the years. Give a rank of 1 to the agent that you have sold the most grain to, a rank of 2 to the second most, etc. Do not give a rank to any agents that you have not sold grain to over the years.

1st	2nd	3rd	RANK
48.1%	23.1%	14.4%	____grain elevator company, (for example, UGG, the Pool, etc.)
36.2	30.6	15.2	____small grain company, (for example, Mancorn, Northern Sales, Linear Agra, etc.)
4.8	15.6	26.4	____feedmill
4.8	14.5	18.4	____distillery
4.8	10.8	16.8	____used as feed for my own livestock
1.4	5.4	8.8	____other, please specify_____livestock_feed_trade_____

* NEXT, WE WOULD LIKE YOU TO REPLY TO 7 QUESTIONS ABOUT YOUR ATTITUDE TO FARMING TODAY.

32. Put yourself in this position. You own 1000 acres of cultivatable land. Your neighbor who farms 500 acres of comparable land 2 miles down the road has told you that he would like to gradually retire from farming over the next few years. He has given you the first option on his land. He is willing to either sell all 500 acres to you at the going price, or rent it to you for 3 years on a cash or share basis. You have enough cash to put in next years's crop on your 1000 and his 500 acres, and you can get as much credit as you require. Which one of the following options would you chose? Please check only 1 answer.

16.8%	___cash rent all 500 acres
28.0	___rent all 500 acres on a share basis
8.4	___buy all 500 acres
7.0	___I would buy______acres, and rent______acres.
35.5	___I would decline my neighbor's offer, and continue to farm my 1000 acres only.
4.2	NO ANSWER

33. Put yourself in this position. You are a farmer who owns 640 acres of cultivatable land. You have enough money in the bank to buy another 320 acres of similar land, and to put in next year's crop on the 640 and 320 acres. You have the option of mortgaging your land, or using your cash to buy the 320 acres. How much of your 640 acres would you be willing to mortgage in ordor to buy the 320 acres? Check only 1 answer.

60.7%	___none
1.9	___1-10%
9.3	___10-20%
13.6	___20-30%
2.8	___30-40%
9.3	___40-50%
2.3	NO ANSWER

* FOR QUESTIONS 34 TO 38, PLEASE INDICATE WHETHER YOU FEEL YOU ARE LIKE, SOMEWHAT LIKE, UNLIKE, OR SOMEWHAT UNLIKE THE PERSON IN THE STATEMENT BY PLACING A CHECKMARK IN THE APPROPRIATE BLANK.

34. John Doe knows that not all new farming ideas and practices are right for his farm. Still, he is always on the lookout for new ways of farming because the new ideas and practices that he has tried over the years have paid off.

50.9%	___LIKE
45.8	___SOMEWHAT LIKE
1.4	___SOMEWHAT UNLIKE
.9	___UNLIKE
.9	NO ANSWER

35. If there is a possibility of making a good profit, Dave Smith does not mind taking a large risk on a farming entreprise. Although it cost him a lot of money, he enlarged his farming operation last year. He felt this would enable him to make much more money.

9.3%	___LIKE
34.1	___SOMEWHAT LIKE
25.2	___SOMEWHAT UNLIKE
29.9	___UNLIKE
1.9	NO ANSWER

36. Albert Black needs to make some improvements to his farm. He could get a mortgage to make the improvements. However, Albert does not like to mortgage, and has decided not to obtain one even though he has estimated that he could pay it off in 3 years.

18.7%	___LIKE
22.0	___SOMEWHAT LIKE
25.7	___SOMEWHAT UNLIKE
31.8	___UNLIKE
1.9	NO ANSWER

37. John Smith thought that if he increased his cash investment in variable inputs in the springtime, he would be able to double his crop production in 2 years. But because John does not like to borrow operating capital he did not make the investment.

10.7%	___LIKE
11.7	___SOMEWHAT LIKE
31.8	___SOMEWHAT UNLIKE
43.5	___UNLIKE
2.3	NO ANSWER

38. Dave White applied an additional $5 of nitrogen fertilizer per acre. He believed that by doing so he had a 50% chance of realizing an additional $10 of revenue per acre.

41.1%	___LIKE
36.0	___SOMEWHAT LIKE
9.3	___SOMEWHAT UNLIKE
11.7	___UNLIKE
1.9	NO ANSWER

* NOW WE WOULD LIKE TO ASK YOU A FEW FACTS ABOUT YOU AND YOUR FARM.

39. How many acres did you have under crop and summerfallow in 1983?________Average=906___________acres

40. How many acres, out of the total you reported in question 39, did you rent in 1983?______Average=342__________acres

41. Which of the following crops, and how many acres of each did you grow in 1983? Please check and fill in the appropriate blanks.

	ACRES GROWN IN 1983	# REPORTING
___wheat	___Average = 347	192
___barley	________ 138	109
___flax	________ 108	106
___rapeseed	________ 143	82
___rye	________ 114	43
___grain corn	________ 325	150
___peas	________ 111	73
___lentils	________ 93	4
other, please specify		
___sugar_beets____________	________ 102	28
___sunflowers_____________	________ 118	25
___hay-alfalfa____________	________ 104	28
buckwheat	60	21
summerfallow	73	10

42. What type of crop insurance do you normally buy? Please check the most appropriate answer.

19.6%	___none
18.2	___hail
43.0	___all risk
18.2	ALL RISK + HAIL
.9	NO ANSWER

43. What proportion of your total grain and oilseed acreage do you normally insure? Please check the most appropriate answer.

20.1%	___0%
2.8	___1-25%
5.1	___26-50%
13.1	___51-75%
56.5	___76-100%
2.3	NO ANSWER

44. How long have you been in active, full-time farming?__Ave=19.7_years

45. What is your age? Check the correct range.

2.3%	___15-24 years
12.2	___25-29
14.0	___30-34
19.2	___35-39
22.0	___40-49
18.7	___50-59
7.5	___60-69
2.8	___70 and over
1.4	NO ANSWER

46. Do you farm in cooperation with anyone? Please check any of the following that most accurately describe the people you farm with.

12.2%	___sister or brother
17.3	___son or daughter
12.2	___parent
3.7	___other relative
2.8	___partner
45.7	___I do not farm with anyone else.
1.4	OFFSPRING COMBO
3.7	PARENT + >1 OFFSPRING COMBO
.9	NO ANSWER

47. Please check the classification that most accurately describes the highest level of education that you have received.

24.8%	___elementary school
48.6	___high school
16.4	___Diploma in Agriculture
2.8	___Bachelor of Science in Agriculture
3.3	___Bachelor's degree other than Agriculture
.5	___Graduate degree in Agriculture
.4	___Graduate degree, other than Agriculture
3.3	NO ANSWER

48. In which of the following municipalities is the majority of your land located? Please check your answer.

15.9%	____Portage
5.1	____Grey
22.9	____Dufferin
9.8	____Thompson
9.8	____Roland
24.3	____Stanley

12.2 ____Rhineland

* LASTLY, WE HAVE 1 OPTIONAL QUESTION . FEEL FREE NOT TO ANSWER IT IF YOU FEEL IT ASKS FOR INFORMATION THAT IS TOO CONFIDENTIAL. HOWEVER, AT THE SAME TIME, WE WOULD LIKE TO REMIND YOU THAT ALL REPLIES WILL BE KEPT STRICTLY CONFIDENTIAL. FURTHERMORE, THE MORE COMPLETE AND ACCURATE ARE YOUR ANSWERS, THE MORE USEFUL ARE THE SURVEY RESULTS.

49. What proportion of the total value, including all land, buildings, machinery, and livestock, of your farm do you owe to the bank or some other credit agency? Please check the most appropriate answer.

36.4% ____0-15%
22.4 ____16-30%
15.0 ____31-50%
10.7 ____51-75%
7.5 ____76-100%
7.9 NO ANSWER

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50. Have you any suggestions concerning production and market information? For example, is there any type or source of information that you would like to see improved, etc.____________

____________No_comment____________63%____________
____________Improve_market_information_____11%____________

Appendix B

EDUCATION

TABLE B.1

Percent Distribution of Score on the Index Mesuring Awareness of Grain Corn Technology (AWARE) by Operator Education

Score	Elementary School	High School	Diploma in Agriculture	One or more University degrees	Per-cent	Num ber	Chi-Square
1	34	45	10	11	100	73	
2	18	49	24	9	100	72	
3	23	54	15	8	100	27	
Percent	25	48	17	10	100	173	7.3

* significant at the 95% level

TABLE B.2

Percent Distribution of Score on the Index Measuring Knowledge of Corn Production Techniques, (CORNKNOW) by Operator Education

Score	Elementary School	High School	Diploma in Agriculture	One or more University degrees	Per-cent	Num ber	Chi-Square
1	26	39	26	9	100	46	
2	21	46	13	7	100	38	
3	20	60	13	7	100	30	
Percent	25	48	17	10	100	173	4.2

* significant at the 95% level

Appendix C

INFORMATION

TABLE C.1

Percent Distribution of Score on the Index Measuring Awareness of Grain Corn Technology by Source of Information Most Frequently Consulted

AWARE Index Score	Most Frequently Consulted Information Source			Per-cent	Num ber	Chi-Square
	Private	Public	Personal			
1	51	41	8	100	74	
2	42	55	3	100	72	
3	30	59	11	100	27	
Percent	44	50	6	100	173	7.4

* significant at the 95% level

TABLE C.2

Percent Distribution of Score on the Index Measuring Knowledge and Use of Recommended Crop Management Practices by Source of Information Most Frequently Consulted

RECOPRAC Index Score	Most Frequently Consulted Information Source			Per-cent	Num ber	Chi-Square
	Private	Public	Personal			
1	49	45	6	100	96	
2	43	52	5	100	56	
3	24	67	9	100	21	
Percent	44	50	6	100	173	4.7

* significant at the 95% level

TABLE C.3

Percent Distribution of Score on the Index Measuring Knowledge of Grain Corn Production Techniques by Source of Information Most Frequently Consulted

CORNKNOW Index Score	Most Frequently Consulted Information Source Private	Public	Personal	Per-cent	Num ber	Chi-Square
1	54	41	5	100	46	
2	45	57	8	100	38	
3	27	67	6	100	30	
Percent	44	50	6	100	114	5.8

* significant at the 95% level

TABLE C.4

Percent Distribution of Operator Education by Source of Information Most Frequently Consulted

Educa -tion	Most Frequently Consulted Information Source Private	Public	Personal	Per-cent	Num ber	Chi-Square
Elem Scl.	48	47	5	100	43	
High Scl.	48	48	4	100	84	
Ag Diploma	31	62	7	100	29	
1+ U. deg.	35	47	18	100	17	
Percent	44	50	6	100	173	6.8

* significant at the 95% level

Appendix D

ATTITUDE TO RISK AND UNCERTAINTY

TABLE D.1

Percent Distribution of Score on Attitude to Risk and Uncertainty Index by Operator Age

RISK Index Score	Operator Age (years) 15-29	30-34	35-39	40-49	50-59	>59	Per-cent	Num ber	Chi-Square
1	6	8	21	19	27	19	100	48	
2	14	18	18	28	18	4	100	77	
3	23	13	20	23	15	6	100	48	
Percent	14	13	20	24	20	9	100	173	17.9

* significant at the 95% level

TABLE D.2

Percent Distribution of Score on Attitude to Risk and Uncertainty Index by Use of Borrowed Capital

RISK Index Score	Percent of Total Farm Capital Value Owed to a Credit Agency 0-15	16-30	31-50	>50	Per-cent	Num ber	Chi-Square
1	56	21	10	13	100	48	
2	42	26	14	18	100	77	
3	46	17	15	22	100	48	
Percent	47	22	13	18	100	173	4.4

* significant at the 95% level

TABLE D.3

Percent Distribution of Score on Attitude to Risk and Uncertainty Index by Proportion of Grain & Oilseed Acreage Normally Insured

RISK Index Score	Proportion of Grain & Oilseed Acreage Normally Insured 0	1-50	51-75	75-100	Per- cent	Num ber	Chi- Square
1	21	10	10	59	100	48	
2	23	6	9	62	100	77	
3	15	13	19	53	100	48	
Percent	20	10	12	58	100	173	5.0

* significant at the 95% level

Appendix E

ESTIMATION OF ACREAGE DATA USED IN ECONOMIC MODEL

Crop acreage records are not kept for the survey region as it was defined in this study. Rather the region is part of two larger crop reporting districts. Therefore grain corn and total acreage had to be estimated for use in the profitability model. Although the total acreage of each and all crops are not recorded for the region, the acreage of crops insured with the Manitoba Crop Insurance Corporation (MCIC) are available for each of the seven municipalities in the region. MCIC records were used to estimate the area of grain corn in each survey subregion for the years 1970-82. Table E.1 reports the number of grain corn acres insured in the total survey region as a percentage of the total insured and total grain corn acres in the province, columns (1) and (2) respectively. Table E.1 indicates that these 2 ratios were approximately constant between 1970 and 1977, and between 1978 and 1982. Both ratios experienced an approximate 27 percent decrease between the two periods, 1970-77 and 1978-82. Manitoba Department of Agriculture and Census of Canada records indicate that regions outside the survey region began to increase their grain corn production in about 1978. Therefore it is possible to assume that the average intertemporal decrease in the two ratios of Table E.1 is due to the growth of grain corn outside the survey region. This assumption implies that the survey region's share of total provincial grain corn acreage has remained approximately constant over the period 1970-82. Therefore the ratio of the survey region's insured to total provincial insured grain corn acres, column (1), was used to estimate the region's share of total provincial acreage. The ratio of subregional to regional insured grain corn acres, Columns (3) to (6) Table E.1, was assumed to represent each subregion's share of total regional acreage. These ratios were multiplied by the estimate of the region's total grain corn acreage to obtain the subregional estimates pre-

TABLE E.1

Survey Region's Share of Provincial, and Survey Subregional Shares of Estimated Grain Corn Acreage in Total Survey Region, 1970-82

Year	Region Provincial Ins'd Corn Acreage (1)	Insured/ Provincial Total Corn Acreage (2)	Subrgn 1/ Region's corn Acreage (3)	Subrgn 2/ /Region's Corn Acreage (4)	Subrgn 3/ /Region's Corn Acreage (5)	Subrgn 4/ /Region's Corn Acreage (6)
1970	.84	.74	.15	.39	.46	.00
1971	.85	.37	.17	.61	.22	.00
1972	.91	.50	.08	.46	.46	.00
1973	.97	.40	.03	.39	.56	.02
1974	.96	.25	.07	.66	.27	.00
1975	.92	.30	.02	.51	.47	.00
1976	.87	.34	.03	.29	.68	.00
1977	.70	.46	.06	.18	.75	00
1978	.65	.13	.17	.17	.66	.05
1979	.63	.14	.14	.21	.60	.05
1980	.55	.16	.25	.15	.53	.07
1981	.63	.18	.28	.19	.48	.04
1982	.61	.19	.22	.19	.55	.11

sented in Table E.2, and used in the economic model.

Census of Agriculture records were used to estimate the total area of crop in each subregion for the years 1970-82. Records of the total area under crops in each subregion for the Census years 1971, 1976, and 1981 were obtained. The area under crop progressively increased in each su-

TABLE E.2

Estimated Grain Corn Acreage by Survey Subregion, 1970-82

Year	Subregion 1	Subregion 2	Subregion 3	Subregion 4
1970	389	1010	1191	0
1971	743	2664	961	0
1972	426	2452	2452	0
1973	274	3557	5107	182
1974	249	2343	959	0
1975	149	3794	3497	0
1976	270	2613	6127	0
1977	346	1037	4320	0
1978	7779	7779	30202	2288
1979	8918	13377	38220	3185
1980	13650	8190	28938	3822
1981	28350	19238	48600	4050
1982	18480	15960	46200	9240

bregion between 1971 and 1981. Census figures indicate this increase was primarily due to a decrease in summerfallow. Therefore the total area under crop in interCensus years was estimated simply by interpolating between Census years. Total crop area estimates are included in Table D.3.

TABLE E.3

Estimated Total Crop Acreage by Survey Subregion, 1970-82

Year	Subregion 1	Subregion 2	Subregion 3	Subregion 4
1970	357900	162400	294100	261400
1971	360200	165200	300500	261600
1972	362500	168000	306900	261800
1973	364700	170800	313300	262000
1974	367000	173600	319700	262300
1975	369200	176400	326100	262600
1976	371500	179300	332300	262800
1977	381900	179800	336200	266800
1978	392300	180300	340100	270400
1979	402700	180800	344000	274400
1980	413100	181300	347900	278400
1981	423600	181900	351700	282700
1982	433900	182400	355700	286700

Source: 1971, 1976, 1981 Census of Canada, Agriculture, Manitoba, Statistics Canada, Cat. No. 96-908