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AN EXPERT SYSTEM APPLICATION TO THE FINANCIAL ANALYSIS OF LENDER CASE FARM RECORDS

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JAMES J. PHILLIPS

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JAMES J. PHILLIPS

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ABSTRACT

AN EXPERT SYSTEM APPLICATION TO THE FINANCIAL ANALYSIS OF LENDER CASE FARM RECORDS

BY

JAMES J. PHILLIPS

The agricultural sector is under financial stress. The adverse economic conditions facing farmers today have resulted in the liquidation of many farm operations. Both the farmers and agricultural lenders are losing money due to the deflation in farm asset values and the decrease in foreign demand for American agricultural products.

Technology continues to change at a rapid pace. New advances in micro computer technology are announced weekly. Artificial intelligence applications are beginning to appear in many sectors of the economy.

This research project represents an attempt to explore opportunities for the farm sector to apply new expert system technology to discover answers to farm financial problems.

An expert system was constructed to assess a firm's financial position and performance using the financial records of the lender. A prototype expert system was constructed using the knowlege and experience of this

researcher acting as both knowlege engineer and domain expert. This prototype was then taken to domain experts to obtain suggestions for improvement. After several interviews with experts, an expert system was constructed that would assess firm viability for dairy farms.

Data from twenty seven case farms was obtained from Farm Credit Services and Farmers Home Administration to test the expert system prototype. The financial data was prepared for use by the expert system using an electronic spreadsheet.

The expert system was tested against three other experts to compare it's decisions with those who perform the same tasks every day in their work. The same variables used by the expert sytem were presented to three loan officers. The decisions of the three loan officers were recorded and compared with those of the expert system.

The results of the test indicated that the expert system tended to make decisions that were in agreement with the loan officers. The results of this test also shed light on how the expert system may be improved in it's financial predictions and assessments. In general this research project showed promise for the future use of expert systems to analyze financial records.

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INTRODUCTION

1.1 Problem Statement

The farm sector has been under considerable financial stress since the early 1980's. The decrease in foreign demand for agricultural products combined with continued overproduction of many farm commodities have resulted in a deflation in farm asset values and the erosion of the net worth of numerous farm businesses. Shepard and Collins (27) point out that the degree of financial stress on farms has steadily increased in the past three decades to the point where today's bankruptcy rates are approaching those of the late 1930's.

The USDA's March 1986 farm financial outlook and situation report (30) states that since 1981, farm income has declined over 25 percent and real value of assets has decreased by nearly one half. A USDA survey contained in this report found that approximately 12 percent of all operators were in serious enough trouble to merit substantial restructuring or liquidation. The survey goes on to point out that although aggregate measures of the farm sector should improve in the next 3 to 5 years, there will be continued deterioration in incomes and wealth for 1986.

Although some operations have been able to remain financially viable in recent years, there are a large number of family farm operations that can no longer sustain their net worth and are likely to leave farming by the end of the decade (30). These farms have used up all their credit reserves and the prospect of bankruptcy or other forms of liquidation are eminent.

1.1.1 Michigan Farm Financial Conditions

The erosion in the value of assets and thus in the net worth of farms has been particularly precipitous in the midwest. However, farms in the state of Michigan, appear to be better off than those of most other states in the midwest. Table 1.1 shows how the decrease in real estate values in Michigan, compare with that of Iowa, other midwest states.

Table 1.1 DECLINE IN REAL ESTATE VALUES
Midwest States, 1981 to 1986.

State	Percentage Decline
Wisconsin	41%
Minnesota	55%
Michigan	31%
Iowa	59%
Illinois	49%
Indiana	50%
Ohio	49%

Source : USDA, Agricultural Resources, Outlook and Situation Summary, April 9, 1986.

A Michigan farm finance survey by Hepp and Hardesty (14) indicates that the slower decrease in land values in Michigan is probably due to the larger number of part time farmers in Michigan with outside sources of income. The 1986 crop year however was unusually wet for Michigan farmers. Rivers all over lower Michigan rose to their highest levels for this century. It is likely that the financial problems caused by this flooding may result in some downward pressure on Michigan land values.

The Michigan farm finance survey reported that of the farmers who responded to the survey, 11 percent plan to discontinue farming within the next 2 years (5.5% per year). This is not significantly higher than the normal attrition rate of 4 to 5 percent per annum. Two important facts were obtained from this survey. First, only 6 percent of the farms were reported to be in the highly leveraged category (Debt/Asset ratio > .70). Second, these highly leveraged farmers hold 28 percent of all debt reported in the survey. If this is representative of the conditions throughout Michigan, then this means that over one quarter of the farm debt in Michigan is held by highly leveraged farmers. If the farm financial stress continues, liquidating this amount of debt could prove to be a major problem to those institutions extending credit to farmers.

1.1.2 Farm Financial Analysis

Identification of farms in serious financial trouble given the proper data is not a difficult task for most loan officers or farm management specialists. Examination of a farm's net worth position on three or four years of balance sheets would detect heavy erosion in asset values and credit reserves. Also most loan officers are aware of those farms that have problems meeting financial commitments because of cash flow difficulties. These farm businesses are classified accordingly and are given more attention in order to protect the security position of the lender.

1.1.3 Loan Classification

Most lenders have mechanisms in place for classifying loans into various categories. The loans are classified for purposes of performance pricing, screening new loan applications, or identifying those farms requiring more attention. Most of this classification is done manually and requires an intensive screening by a competent analyst.

1.1.4 Complicating Factors

Although financial measures can be used to classify farm loans into various categories, performing an analysis for diagnostic and prescriptive purposes requires more information. The following factors complicate the task of performing farm business analysis:

1) The interpretation a loan officer or farm management specialist gives a performance indicator varies with firm type. For example the amount of total capital investment for a dairy farm is different than that of a beef farm. There are different norms as to what is considered an acceptable return on investment for the two firm types.

2) Prevailing macro economic conditions influence the importance of many financial performance indicators. Factors such as inflation and interest rates can change direction at any time. Increasing owners equity taking place during an inflationary period would be interpreted differently than if it takes place during periods of asset value deflation. Financial measures therefore need to be interpreted according to the prevailing economic conditions.

3) Several years of financial information is needed before adequate business trends can be established. Financial ratios obtained from the balance sheet for a one year period provide little information to the manager or lender for assessing firm performance unless compared to industry standards or previous years.

4) In addition to distinguishing between firm types, consideration must be given to the specific circumstances of the case being analyzed, such as type of business organization or the size of the farm family. Until recently the business decisions of a corporation had different tax consequences from those made by a sole proprietorship.

5) The accuracy of financial information is illusory and at times incomplete. Many farm businesses have yet to assemble accurate financial information. This is complicated by the fact that many farm accounting systems are inconsistent.

6) Determination of the market value of assets is a subjective process. Farm lenders tend to appraise machinery at salvage value (what it could be sold for to them less any liquidation expenses) while

farmers tend to value their machinery according to what it could be sold for on a dealers lot. The difference between these two values can be very large.

1.1.5 Expert Systems for Problem Solving

The above points are an illustration of the diversity of the farm business environment and that analysis of farm businesses involves the consideration of many variables. Arriving at the proper conclusions requires the integration of diverse sources of knowledge. In such an environment there are no mathematically tractable models that would lead to an algorithm for computing a correct assessment of business performance. Each case has to be analyzed on its own merits.

Computerized expert systems show potential for solving problems in this context. They can be used to represent knowledge, are not driven by formal reasoning methods, and can be adapted to represent the flow characteristics of the problem at hand. Hayes-Roth, et. al. (13) give reasons for the consideration of expert systems or a knowledge based systems approach to problem solving:

"... most of the difficult and interesting problems do not have tractable algorithmic solutions since many important tasks originate in complex social or physical contexts which generally resist precise description and rigorous analysis."

Fiegenbaum (10) indicates that many tasks lack an analytically tractable core. As a result more and more attention is being turned to areas where analytical methods are not known but where people are still able to achieve results.

Expert systems have shown to be a viable problem solving format in the areas of medicine, molecular genetics, structural analysis and adaptive control. An expert system embodies organized knowledge concerning a specific area of human expertise and thus can aid in decision support in the same manner as a skilled consultant (7). There are still a broad range of problems however, where expert system tools have not yet been applied.

There are many farms experiencing financial difficulties in today's rapidly changing agricultural sector. Some specific tasks an expert system could be used for to help alleviate these problems are :

1). Diagnosis of financial problems
2). Prediction of farm business solvency
3). Classification of loans according to risk or financial position

An expert system could be used to interface with a farm accounting system to automate the process of financial analysis. An expert system could assist lending institutions by focussing on important financial variables to obtain periodic assessments of a firms credit risk. The expert system could assist farm managers by analyzing year end income statements to highlight potential sources of problems in the business. The potential applications of expert system technology are plentiful. The area of farm financial analysis represents one such area where the application of expert system tools shows promise.

1.1.6 Statement of Need

Lenders and farmers both need to know if the business is moving toward serious financial trouble. An expert system that would identify sources of financial problems could assist managers and lenders in preventing business failure. Computerized methods of financial analysis could reduce the time required for processing loan applications and reviewing yearly financial data of existing case farms. This would reduce the time required for farm business analysis and in turn allow more time for detailed analysis of those farms in need. This could lead to better business decisions and thus contribute to a reduction in farm financial stress.

1.2 Research Objectives

There are three main objectives of this research. 1) To assemble a set of standards for certain farm management measures. These will be used for diagnostic purposes to analyze the loan records of dairy farms in Michigan. The goal will be to assist in discovering possible problem areas of the business. 2) To construct a set of decision rules that will categorize farms according to their financial position, credit risk and likelihood of financial solvency. 3) To evaluate the feasibility of expert systems as a diagnostic tool for farm financial analysis by comparing the results of the expert system with those of practicing experts in the field.

1.3 The Research Document

There will be an introduction and a more in-depth discussion of the expert system approach to problem solving in chapter two. This problem solving approach has developed a rather unique vocabulary. This chapter acquaints the reader with the evolution of expert systems and how expert systems fit into the fast growing field of artificial intelligence. It will also provide the reader with an adequate introduction to the terminology and concepts of expert systems in order to

facilitate a better understanding of the application of these tools in this study.
Chapter three is a literature review of work that addresses problems important to the development of the decision rules relevant to the knowledge base of this expert system prototype. The knowledge in this expert system model draws from research in dairy farm management and agricultural finance. Relevant studies and research documents in these two areas will be discussed.

A discussion of the methodology used to build the expert system model is provided in chapter four. This chapter gives a description of the steps used for determining the appropriateness of the expert system approach. It also identifies of the source of the knowledge in the expert system prototype along with a specific description of the manner in which the knowledge is represented in the expert system.

Chapter five presents the results of the expert system model for each of the case farms used in the analysis. These results are compared to the decisions and predictions of 3 loan officers. The limitations and weaknesses of the expert system model is discussed and potential improvement from a revised version of the expert system is discussed.

The final chapter presents a brief summary of the conclusions from the study. This chapter will also include suggestions for extending the expert system model used in this research and insights for future problem solving exercises using the expert system approach.

CHAPTER II

THE EXPERT SYSTEM APPROACH

The following is a brief introduction to the history, concepts and nomenclature of the expert system problem solving approach. Expert systems is a fast growing branch of applied artificial intelligence. Researchers are working with this new technology to find new ways for solving problems. New developments in the field of expert systems are being introduced weekly in computer literature as research brings this technology to bear on new problems.

2.1 Why Expert Systems

The theory of decision making is a broadly studied area with a strong influence on management science. Behavioralist decision theory seeks to explain the nature of the human mind as a selective, sequential information processing system with limited information processing and memory capacity. Hogarth (16) points out the limitations of human decision makers and the manner in which they make judgmental errors due to the limited capacity of the human mind. Humans tend to impose illusory patterns on what they observe. They employ cognitive simplification strategies which can often result in an oversimplification of the problem at hand. The tendency is to focus on specific facts of a case and to ignore base rate information.

An example of the tendency of humans to ignore base rate information is given by Hogarth where he speaks of a cab involved in an accident. It is known that 85% of city cabs are green and 15% are blue. A witness who testified in seeing a blue cab is known to have made correct predictions 80% of the time under those visibility conditions. Most people would say that there is then an 80% probability that a blue cab was involved in the accident. However when the base rate information is considered (15% of city cabs are blue) the correct answer is 41%. Hogarth goes on to point out that this is due to the fact that peoples intuitions do not correspond to the laws of probability due to their failure to consider base rate information (16).

Rationalist decision theory is a highly formalized, logical approach that seeks to determine how a decision maker with a consistent set of preferences, orders choices to arrive at a calculated best solution. Designing formalized rationalistic models of decision making that consistently order choices for a decision maker have not met with great success in solving problems for a number of reasons. This could be attributed to the difficulty of quantifying the complex environments where decisions are made and adequately formalizing a decision makers utility (23).

Expert systems are a decision tool that can model human decision making. The symbolic nature of expert systems do not require mathematically formalized descriptions of the decision making environment. By making use of symbolic representations such as those in a simple decision tree, an expert system can bring nonquantifiable information to bear on a problem. In this way it can work as a complement to more formalized problem solving approaches such as simulation or optimization models.

In addition to acting as a complement to formalized mathematical decision models expert systems can be used in the behavioralist context to support decisions of managers thus assisting to overcome the flaws of human decision makers.

The knowledge contained in expert systems is obtained from human experts or other reliable sources. During the expert system model building process, the problem at hand is carefully outlined so as to arrive at a conditional best solution every time. The knowledge used to solve this problem can be represented in such a manner so as to sequentially process decision rules and thus bypass the erroneous simplification strategies employed by human decision makers who often are required to make snap judgments.

2.2 History of expert systems

It was through research in applied Artificial Intelligence where the expert system problem solving approach had it's beginnings. Artificial Intelligence (AI) is a discipline that examines questions about human intelligence and behavior. It embodies such fields as cybernetics, psychology, philosophy and linguistics so as to incorporate the cognitive decision making processes of a human into a machine. Presently there are computer programs that can play chess at the level of a grand master. James Albus (8) holds a patent on the Cerebellar Model Arithmetic Computer that he says has an architecture capable of reproducing many functions of the human nervous system. These programs incorporate human attributes including problem solving approaches. However, many people would question if these programs actually think. The application of AI tools has spawned an active debate on the nature of machine and human intelligence.

Hubert and Stuart Dreyfus (8) have argued that machines will never think like humans. They believe true expertise exists at too many levels for simple rule and symbol manipulation to represent. Therefore programs such as expert systems will only be able to perform at low levels of skills.

Winograd and Flores (8) point out that current AI research is well suited to rationalistic problem solving procedures using heuristics. They also point out that computers have the wrong structure to perform like human decision makers since computers process symbols without regard to their meaning while humans process everything within a framework of interpretations. They conclude that it therefore makes sense to design computers not to behave more like people but to assist people to perform tasks more efficiently.

Whether or not computers will ever be able to think or expert systems will ever approach the performance of a human expert is a question that only further research in this area will answer. The large number of expert system tools currently available on the market however are already changing the way in which knowledge is being accumulated and disseminated.

Expert systems began to emerge around the mid seventies. Because many problems do not conform to the rigor of mathematical representation, scientists began to explore the possibility of using computers for symbolic processing. Originally it was thought that general domain independent problem solving methods combined with laws of reasoning and processed by powerful computers would be able to imitate human intelligence (10). Davis points out how from this early work it became evident that these general theoretical methods were overwhelmed by real world complexities due to the need for large quantities of task specific knowledge (7). The limitations of this more generalized problem solving approach led researchers to begin work on more narrowly defined applications.

Two successful projects that have been at the forefront of expert system development are DENDRAL AND MYCIN. They are designed to solve problems for very narrow and specific applications and, as with all of the successful expert systems, were developed over a period of many years. These expert systems have led to the development of expert system shells which provide the reasoning process and the development routines for developing problem solving tools. These shells have separated the knowledge base from logic and search routines (inference engine) used to reach conclusions. This facilitates the use of the knowledge base for various applications such as explanation, knowledge acquisition and tutoring (7). In addition it allows for the substitution of the existing knowledge base for a new knowledge base designed to solve a different problem.

DENDRAL, one of the earliest acknowledged expert systems (1965) and developed by Edward Fiegenbaum at the Stanford Heuristic Programming Project, identifies organic compounds by analysis of mass spectrograms. Because conventional programming could not allow for the inferring of complex molecular structures, DENDRAL evolved as a rule based system using a series of situation => action rules (13). It is this type of production rule system that led to the development of other more well known expert systems such as MYCIN and EMYCIN.

MYCIN (1975) was developed by Edward Shortliffe also at the Stanford Heuristic Programming Project. This program diagnoses blood and meningitis infections and recommends appropriate drug treatment. This program was instrumental in the evolution of the expert system shell as a way of representing knowledge. MYCIN is a production rule system comprised of over 400 if/then rules which have an associated degree of certainty or certainty factors. MYCIN uses a backward-chaining control strategy. This means that a goal is chosen first, then rules are selected by an internal control structure and recursively fired until the original goal is achieved. Each rule nested in such a manner that the antecedent to one rule would be the conclusion to the previous rule.

Because the structure of the MYCIN system is so easily understood this has led to the development of EMYCIN. EMYCIN is a prototype expert system shell emulated by many current expert systems application tools (13) available today.

2.3 Expert System Components

Expert systems are a branch of applied AI. The emphasis is on knowledge and how it is organized to solve problems for a specialized professional domain. The expert system is normally made up of a collection of heuristic rules acquired from an expert and organized in a logical manner so as to reach a conclusion for a specific problem. Expert systems can be thought of as a useful tool for modeling a decision tree.

2.3.1 Knowledge Base

When building an expert system, knowledge as related to a particular problem is encoded in various forms by a person referred to as the knowledge engineer. There are a variety of methods for representing knowledge such as frames, semantic networks, predicate calculus, object-attribute-values and production rules. The manner chosen for knowledge representation depends on the nature of the problem at hand.

Frames along with semantic networks allow the knowledge engineer to achieve a great level of detail. Many complex biological or mechanical processes conform well to a frame or semantic net representation of knowledge. This is because these forms of knowledge representation allow for the encoding of knowledge with a great level of detail. One of the more simple methods for representing knowledge is with object-attribute-values triplets or production rules.

Production rules connect object-attribute-value knowledge with simple clauses using logical operators. In this manner a decision tree can be represented to model a problem using IF, AND, THEN, ELSE types of statements that connect object-attribute-value clauses

(13). Figure 2.1 is a simple example of a simple object attribute value triplet clause.

Figure 2.1 Object => Attribute => Value Example

```
       OBJECT          ATTRIBUTE      VALUE
         ^                 ^            ^
If debt asset ratio  >  .70 Then debt asset ratio is high.
```

2.3.2 Inference Engine

The inference engine is the underlying search mechanism or control structure used to sift through the knowledge base to retrieve facts that apply to the conclusion for a particular problem. The inference engine also checks for inconsistencies in the knowledge base. Various inference engine types are available to process information symbolically. The two most common methods of reasoning in rule based systems are the backward chaining and the forward chaining control strategies.

Backward chaining systems start with a goal and work backward through the rules causing the antecedents to each rule to become a new goal. Information is asked of the user once the system encounters rules whose antecedents have to be elicited.

Forward chaining reasoning starts with data provided by the user or read into the knowledge base and applies all those rules whose antecedents have been satisfied. This results in the application of many rules as one rule provides the conclusion used in the antecedent for another.

2.4 Certainty Factors

Knowledge can be expressed in terms of certainty factors which allow for inexact reasoning to be incorporated in to the knowledge base. For example a conclusion to a boolean rule (rule requiring a true or false answer) may be expressed with only 80% certainty. These certainty factors are not associated with a probability distribution. Harmon and King state that they are informal or subjective measures of confidence or certainty associated with a piece of evidence (10). These certainty factors arise for such reasons as inadequacies in the data or stochastic relationships between propositions.

Statisticians are actively researching the topic of certainty factors. This research may result in an extension to Bayes theorem which in it's present form does not indicate how information of less than complete reliability should be treated, nor how information should be utilized that is not expressed as a probability (23).

Because of the lack of formalization in this area of decision making, ad hoc techniques have been developed for combining these certainty factors as the inference engine recursively works through the rules of the knowledge base. The manner in which these certainty factors are combined is a subject of considerable debate. However as Davis (6) points out, it may be of secondary importance.

> "....most of a systems performance seems to arise from having the rules at all, that is, knowing which facts lead to which conclusions."

The focus is on the knowledge contained in the expert system and how it is adapted to the flow characteristics for solving the problem at hand. The knowledge base is the most important component of the expert system and should ultimately determine the success of the expert system in solving the problem at hand.

2.5 Knowledge Engineering

The process of obtaining information and encoding this information in a knowledge base is referred to as knowledge engineering. This encoding process is performed by a person referred to as the knowledge engineer. The knowledge engineer extracts knowledge from various resources such as books, publications and domain experts. The domain expert is an individual who has experience and knowledge in the problem area addressed in the expert system. Sometimes the domain expert and the knowledge engineer can be the same person.

Depending on the degree of complexity of the problem, the knowledge engineer will spend much time in detailed interviews with the domain expert capturing the flow characteristics of the problem at hand. The domain expert provides the rules of thumb, fuzzy reasoning and the architecture of the rules in the knowledge base.

2.6 Knowledge Formalization

A valuable result that comes from the expert system development process is the formalization of knowledge. Relationships between factors that influence a problem are fully developed which helps make clear the knowledge required to adequately solve a problem. Gaps in the knowledge about a certain problem are made more explicit. The expert system development process as in many other problem solving approaches, leads to a better conceptualization of the problem to be solved.

2.7 Expert System Applications in Agriculture

Expert system applications are starting to appear more frequently in agriculture. Expert systems have been used in agriculture in the areas of market strategy selection, soybean disease diagnosis, determination of irrigation requirements for cotton, determination of soil liming requirements and linear program interpretation.

2.7.1 Soybean Disease Diagnosis

R.S. Michalski and R.L. Chilausky compared two methods of knowledge acquisition for building an expert system to diagnose soybean diseases (18). Two soybean models using a production rule system were constructed. One using rules derived through the interviewing of an expert and formalizing the knowledge in rule form, and the other through inductively inferring the rules from examples of the decisions of an expert.

The performance of the inductively derived decision rules was better than the expert derived decision rules. The inductively derived decision rules were 97.6 % correct when using the rule with the highest degree of confirmation verses 71.8 % with the expert derived rules. Correct diagnosis is defined by the authors as a diagnosis that would match that of a plant pathologist. The authors also constructed an indecision ratio to measure the "cleanness " of the rules. The inductively derived rules were less indecisive using this measure compared to the expert rules. In other words they involved less nonessential information.

The authors cited two possible reasons for the poorer performance of the expert derived decision rules. One was the fact that experts are trained in making decisions and not explaining the process of their decision making. This is perhaps why examples of the experts decisions are more reliable than experts descriptions of these decisions. The other involves the time required to encode knowledge in a precise enough manner so as to construct an efficient decision rule. Perhaps more time spent with the experts could have led to a refinement of the knowledge, and thus better performing rules.

2.7.2 Grain Marketing Model

Purdue University has developed a grain marketing expert system that selects a grain marketing alternative based on such things as a user's risk preference, price trends, basis trends, harvest date and storage availability. The grain marketing model was developed using an expert system shell sold by Texas Instruments called Personal Consultant. This is a shell written in LISP which uses the production rule language as a method for encoding knowledge.

The grain marketing model program in the form it was presented in American Society of Agricultural Engineers (ASAE) (29) was a collection of about 50 heuristic decision rules designed to present the user with alternative marketing strategies. It has since been updated with more rules with a more refined user interface.

Some of the most difficult questions dealt with in this program are the ones that are asked of the user. The prediction of price trends and basis trends are the hardest part of the grain marketing decision process. This program does provide an architectural representation of the sequential decision making required in the selection of a marketing strategy. Examination of this program also brings to light the potential power of interfacing expert systems with algorithms that could perform technical analysis to obtain answers to these difficult questions such as determination of price and basis trends.

2.7.3 A Linear Program Interpreter and COMAX

Two expert systems developed for agricultural applications that work together with other programs are COMAX and a linear program interpreter. COMAX is a rule based system that runs a cotton simulation model. The other is a rule based system developed on Personal Consultant that interprets linear programming output for a machinery selection problem.

COMAX (17) runs a computer simulation model called GOSSYM each day under three different weather scenarios and computes the date that irrigation will be required in a report printed at the end of the daily operation. These irrigation dates change as each new day passes and the information in the knowledge base in updated.

The linear program interpreter developed by Bender and McCarl at Texas A & M (2) extracts information from the output of the post optimality analysis of an LP model and recommends machinery selection strategies that will increase profitability.

These two programs because they interact with powerful algorithms illustrate the great potential that exists for expert system integration into an overall decision support system context. This is the eventual long term goal of the prototype being developed in this research project.

CHAPTER III

LITERATURE REVIEW

3.1 Introduction

This research project involves the construction, testing and evaluation of an expert system prototype. Since expert systems are a relatively new area, few studies are available that are of a similar nature. The topics of this research project cover a broad range of disciplines from agricultural finance to dairy farm management to expert systems.

This chapter will focus on studies and texts relating to farm finance and dairy management. The source of the knowledge contained in the knowledge base of the expert system will be discussed in the context of the knowledge acquisition stage of expert system development in the chapter to follow. The first part of this chapter will examine literature that addresses issues related to farm financial solvency. The second part will touch on some of the issues of dairy farm management that are directly related to this research.

3.2 Assessing Firm Solvency

There are few studies in the literature that deal directly with the prediction of financial solvency of farm firms. The few studies that address the problem of solvency prediction are more macroeconomic in orientation, attempting to assess national trends, rather than predicting problems for a specific class of firms. The studies involving credit scoring, are not directly attempting to assess firm viability but rather are involved in the partitioning of loan portfolio's into various risk categories for purposes of performance pricing (varying interest rate with risk). The studies referred to in this section of the literature review do however provide some insight for determination of the important financial variables to be considered when building a knowledge base for financial analysis.

3.2.1 Farm Bankruptcies

A study by Shepard and Collins (28) entitled "Why do farmers fail?", used least squares regression to obtain a broad class of explanatory variables that would be able to explain the rate of farm bankruptcies. The data in this study was divided into two main periods, pre-war (1910-1940) and post-war (1946-1978). Using the rate of farm bankruptcy filings as the dependent variable for the pre-war period, statistically significant independent variables were: farm size, debt asset ratio, government support payments as a proportion of revenues and the rate of non-farm failures. For the post-war period, using the same dependent variable, the significant variables were real net farm income, farm size and the rate of non-farm failures.

Real net farm income was not significant for the pre-war period but was statistically significant for the post-war period. The authors point out that the indefinite relationship between real net farm income and bankruptcy for the pre-war period suggests that farms were relying less on off-farm inputs producing more for home consumption. These farms were thus more capable of withstanding variability in farm income during this period. The authors go on to point out that the increased use of debt financing combined with decreasing land values seem to have been the dominate reason for failure during the pre-war period, similar problems to those faced by farmers today.

For the post-war period, financial leverage shows little relationship to bankruptcy, probably due to the rapid increase in land values for the time period being analyzed. Farm income for the post-war period emerges as an important variable due to farms becoming more capital intensive creating an increased reliance on inputs produced off the farm. This increase in capital intensity requires a higher income to offset the higher cost structure.

Government support payments was found to be a significant variable for both periods. This follows since government support is more of a response to adverse economic conditions rather than a force used to change conditions.

With two separate sets of indicators explaining bankruptcy in two time periods, the importance of the general economic environment for carrying out business analysis is evident in this study. The manner in which farm size shows up as an important variable in both time periods for different reasons emphasizes this point. Larger farm size was associated with lower bankruptcy rates in the pre-war period and with higher rates in the post-war period. The authors state that perhaps the larger farm size bears higher risk and thus was more likely to fail in the post-war time period. Before any definite conclusions can be made, the causal link between bankruptcy and farm size needs further investigation.

Non-farm bankruptcy filings was an important variable for both time periods. This is important in that it is probable that the general macroeconomic conditions caused an increase in the rate of the non-farm failures. It follows then that the macro-economic conditions exert strong influence on farm business failures.

3.2.2 Factors Affecting Farm Survival

Another study by Perry et. al. (26) used a simulation model to evaluate the effects of beginning equity, the inflation rate for land, and credit policy on the survivability and ending equity position for a Texas rice and soybean farm. Results for a fully leased farm were contrasted with that of a part owned farm.

The authors used a firm level monte carlo simulation model to recursively simulate through successive time periods the farming operation using the current years ending financial position as the next years beginning position. Any farm without a positive cash balance at the end of the year was liquidated. Annual production, farm policy, marketing, management and income taxes were simulated along with random prices and yields. The results of the study pointed out the importance of owners equity on farm survival. Starting at 40% equity and deflating land values at the rate of 3% annually resulted in a 24% probability of survival under the most liberal of credit policies for a part owner. However, once the initial equity position reached 75% there was a 100% survivability under any credit policy scenario. Owner equity or capital structure was the dominant variable that best determined the survivability of a farm firm.

3.2.3 Predicting Farm Business Viability

A study by J. R. Crabtree (5) evaluated critical indicators as predictors of farm business viability. He chose to avoid using the net worth figure since it can be maintained through appreciation in capital values. Obtaining the net worth figure also requires a comprehensive business analysis. He therefore looked for another measure that could be obtained directly from the income statement. It was hoped that this measure in addition to providing insight to firm capital structure could also capture possible problems from losses of liquidity.

The following five predictors of viability were examined: 1) rent and interest expenses as a percent of adjusted net profit, 2) rent and interest expenses as a percent of gross output, 3) gross margin expressed as a percent of gross output, 4) machinery costs expressed as a percent of gross output and 5) hired labor costs expressed as a percent of gross output. The best predictor of business viability was found to be rent and interest charges as a percent of gross output (RI).

Overall, the author found that farms with an RI ratio higher than 14% had to rely on capital appreciation to maintain net worth and farms with an RI ratio over 20% will likely be unable to sustain net worth over the long term even with some capital appreciation in land.

These findings, although useful for this study, should be viewed with caution. There is a danger to develop the same standards for similar farms operating in very different ecological and economic environments. Because this study takes place in the United Kingdom, it may be that farms are operating on a different capital base than farmers in most parts of the United States. This means reliance on different amounts of debt financing. Therefore, a standard measure of interest and rent expenses as a percent of gross output across different geographical locations may not be appropriate.

Also, yearly fluctuations in output may cause a firm such as a crop farm to rely more heavily on borrowed money than a dairy farm in any one given year. A high RI ratio may only be a temporary condition. Because a dairy farm should not suffer from the same degree of fluctuations as a crop farm, a high RI ratio in a dairy farm operation may reflect mismanagement problems with the business that have resulted in an increased reliance on borrowed money over time.

This emphasizes the point that any general conclusions using one financial measure as a predictor of business viability would have to be treated cautiously. However, this study does indicate one measure that may prove to be very helpful in predicting business solvency if viewed in the proper context.

3.2.4 Credit Scoring

The credit scoring literature provides some useful insight into the financial measures that might be important for predicting farm business survival. Most credit scoring is performed with a linear discriminate function that classifies items into predetermined groups. The technique, referred to as discriminate analysis is based on the assumption that a linear function exists that can distinguish between elements of a population. The goal of the linear discriminate model is to choose variables whose coefficients in the discriminate function maximize the ratio of the sum of squares between two groups (9). The end result is a list of variables that best distinguish between two groups of a population.

Several studies have used discriminate analysis to classify loan applications into successful and unsuccessful groups or categories (9). Nonfinancial criteria such as family size and marital status were found to be important variables in some cases. The number of acres and the ratio of non-real estate debt to total debts were also found to be important. The most important variable however, in a majority of the studies was the debt/asset ratio.

The data used in most of these studies with a few exceptions has come from information on loan applications. This information often does not include a breakdown of different expense categories generally used for assessing the performance of certain farm types. This is most likely due to the variety of farm types that apply for loans. The objective of discriminate analysis is to divide a diverse population of loan applicants into groups. Operational measures therefore, have little explanatory meaning for this purpose unless one is comparing between homogenous firms. Therefore these measures are for the most part excluded from the explanatory variables of the discriminate functions in these studies.

Since the goal of credit scoring models is to classify loan applications into good and poor performance groups, the variables found to best distinguish between good and poor performing loans should provide a useful starting point for setting up the problem of assessing farm business viability.

3.2.5 Conclusions

The study by Sheppard and Collins highlights the importance of the general business climate. Financial variables used to assess firm viability should not be considered apart from the macroeconomic environment which has a strong influence on the rate of business failure. Therefore a knowledge base system that assesses firm viability should consider the effects that inflation and deflation have on the balance sheet of farm operations. Also firms should be compared across similar time periods where they are all operating under the same set of economic conditions.

Nonfinancial factors may be helpful in predicting financial solvency. The credit scoring literature, such as the study by Dunn and Frey, point out that variables such as family size, type of business organization and age of the farm operator/manager assist in prediction of success in a farm business. For purposes of this study it may then be helpful to know the type of business organization before making a statement regarding the viability of the farm business.

The debt/asset ratio or capital structure is likely to have a dominating influence in any study regarding financial viability as pointed out by all of the above studies. A key performance measure for firm growth is owners percent equity, which when subtracted from one yields the debt/asset ratio.

Certain measures such as interest and lease expense as a percent of gross income discussed by Crabtree, have been shown to be a quick measure for assessing business viability. This variable represents a good indicator for aiding a manager as a means of assessing firm risk, to help assist in the prediction of cash flow problems.

3.3 Dairy Farm Management

3.3.1 Purchasing verses Growing Feed

Several attempts have been made for developing standards of measurement for management factors on dairy farms. A study by Joe Hlubic (13) compared the profitability of growing verses purchasing feed for dairy farms in Michigan. In this study he constructed a model that compared the returns on initial investment for farms that 1) grew all necessary feed, 2) grew forages only, and 3) purchased all feed. These three scenarios were modeled under various commodity price and animal production scenarios.

He found that with higher productivity in the animals, it paid more to invest in the expansion of animal facilities and less to invest in feed crop enterprises. At levels of production of 13000 lbs it was more profitable to grow all feed. However, once production reached 15000 lbs it became increasingly more profitable with increased levels of production, to purchase all feed.

The results from this study are helpful for addressing tactical questions such as how farms should expand or how a farm operator should invest if starting a new business. They are not of significant help for strategic decision making on farms that have already made the investment decision and want to determine whether or not it is profitable to idle their machinery and land to purchase feed in a given year.

3.3.2 Dairy Farm Analysis

Using the financial records of MSU's Telfarm system, the results from the study by Hlubic were eventually used to develop management guidelines for existing farms. These guidelines were published in a MSU extension bulletin (28). Certain guidelines from this bulletin represent good management criteria for representation in an expert system model.

CHAPTER IV

KNOWLEDGE ACQUISITION AND FORMALIZATION

4.1 Introduction

One of the main goals of this research project is to build and test an expert system. The domain for the problem to be solved is farm management and finance. Because the task of encoding knowledge in an expert system requires a large investment of time and effort some steps should be taken to insure a proper match between the problem and the expert system problem solving approach.

This chapter will start with a description of a process outlined by Waterman (34) for analyzing the applicability of the expert system approach to solve a particular problem. This will be followed by a discussion of the process used to select the expert system tool used in this study. Finally the rules in the expert system and the sources of the knowledge for these rules will be discussed.

4.2 Expert System Applicability

Developing an expert system as with any decision support system is an evolutionary process. It is a project that is never complete, one that is subject to constant revision, reformulation and augmentation.

The following steps were taken before this research began to assure a proper match between expert system tools and the problem studied in this research. These steps outlined by Waterman (34) list some of the criteria to be considered before using expert system tools. The three steps of evaluating the applicability of expert system tools for a particular problem are referred to by Waterman as; suitability, justification and appropriateness.

4.2.1 Suitability

To evaluate the suitability of expert system tools for application to the problem at hand, Waterman provides some characteristics for expert system oriented tasks below.

1. Task does not require common sense
2. Task requires only cognitive skills
3. Experts can articulate their methods
4. Genuine experts exist and agree on solutions
5. Task is not too difficult but is well understood

The introductory chapter of this research document provides some reasons for selecting expert system tools to diagnose farm financial problems. The task of diagnosing financial problems requires the integration of diverse sources of knowledge and is performed by people with specific training. Thus it requires the "common sense" of specifically trained people fulfilling the first characteristic. It is a repetitive task and is performed on a daily basis by farm management specialists, loan officers and others who use knowledge and judgement, therefore it fulfills the second and fifth characteristic.

Evaluating the problem for the third characteristic is more difficult. Experts are not always able to articulate their methods. It takes a skilled knowledge engineer to elicit the heuristic techniques that people use for problem solving. For this project, loan officers and farm management specialists had difficulty in verbalizing the steps they used to analyze financial statements. However, the inability of an expert to articulate their problem solving techniques is very common. Harmon and King (10) point out that all expert systems are not elicited from experts. Various techniques such as constructing rules by induction or demonstration of the reasoning processes of a prototype to an expert, can be used to elicit their heuristic knowledge.

The expert system for this project was initially developed in prototype form. The sequential decisions for financial analysis were outlined and encoded in the knowledge base before expert knowledge was solicited. The prototype was demonstrated to several experts who were asked to evaluate the heuristic process used to perform the analysis. Therefore, considerable time and effort had been invested in the project before the problem could be considered suitable according to the third characteristic.

The potential problems for evaluating the suitability for the fourth characteristic was recognized. Experts in many disciplines often disagree, and the field of agricultural finance is no different in this respect. The source of disagreement in many fields is often the result of institutional or geographical bias. That is, decision makers from different organizations develop their own standard operating procedures for approaching similar problems. When testing and working with experts on this model, the work was done with experts from lower Michigan most of whom were affiliated with Michigan State University. This helped to eliminate disagreements due to any organizational biases.

It is also worth pointing out that there is agreement on the fundamental concepts of agricultural finance and firm growth. It was with these concepts that the core of this knowledge base was constructed.

As the above discussion shows, a preliminary decision was made that expert system tools were suitable for the problem even though there may not have been a perfect match with Waterman's criteria. Thus the determination of the suitability of expert systems as defined by Waterman occurred later during the development process.

4.2.2 Justification

After the determination of suitability, Waterman provides conditions any one of which would justify the investment of human resources and effort to develop an expert system.

- task solution has high payoff
- human expertise is being lost
- human expertise is scarce
- expertise needed in many locations
- expertise needed in a hostile environment

There was little problem in justifying the task at hand since the problem meets a number of the conditions listed above. For example the problem of farm financial analysis has a high payoff. It could help farm managers prevent financial failure and assist lenders in making good lending decisions. The expertise of analyzing farm financial statements is needed in many locations and is sometimes scarce.

Justification of the problem at hand is an important decision for a corporation that may expend valuable resources for the development of an expert system. The criteria listed above will ultimately determine if the venture will be marketable or cost effective. Although some of these concepts may seem obvious, these steps are worth serious attention in order to assure that the expert system project is seen to completion.

4.2.3 Appropriateness of Expert Systems

Waterman provides 5 characteristics that a problem should have if the expert system approach is to be considered appropriate.

1). task requires symbol manipulation
2). task requires heuristic solutions
3). task is not too easy
4). task has practical value
5). task is of a manageable size

These set of conditions are perhaps the most important of the consideration process because they are not always intuitively obvious. For example, some problems are better solved with spreadsheet tools or with algorithms using a lower level language such as Fortran or Pascal. If a mathematical algorithm can be written to represent a problem, then the heuristic nature of expert system problem representation would be cumbersome. The problem to be solved for this research represents one that requires conditional information best represented in a heuristic format.

The need for symbolic processing is also important. If a problem only requires the manipulation of numerical data with numerical operators, it makes sense to use a lower level language. The strength of expert system tools is the fact that they manipulate information with logical operators such as if-and-then conditions. Many expert systems are designed to interface with programs that perform the numerical calculations and pass the necessary parameters back to the inference engine. Manipulating numerical data without sufficient heuristics would be accomplished much faster with a language such as Pascal or Fortran and would not be an appropriate environment for using expert system tools alone.

A task that is too easy would not be worth the time and effort of expert system representation. For any expert system project particularly for a commercial venture the costs and benefits must be weighed before undertaking expert system development. This will determine if the

task is of practical value. It is hoped that the expert system designed for this research would be of practical value to loan officers and extension agents.
The fifth characteristic states that the task must be of a manageable size. Diagnosing financial problems for all of types of Michigan farms would be a very large task. The problem of diagnosing farm financial troubles was reduced down to a more manageable size by selecting only dairy farms for the analysis. In light of this, it is hoped that this expert system may eventually be a branch in a much larger knowledge tree that focuses on all of the farm types in Michigan.

The problem was also reduced to a manageable size by concentrating on an expert system that would assist in preliminary diagnosis of management problems using loan records. Constructing the decision rules that would be needed for a complete diagnosis would be a much larger project and would require more specific data.

4.3 Expert System Tool Selection

Once the expert system approach is considered appropriate, an expert system development tool or shell must be selected. When selecting a specific development tool for this research project these are a few of the key items considered in the selection process.

1. the applicability of a given inference engine to appropriately model the flow characteristics of the problem at hand
2. cost of the system
3. ease of learning
4. flexibility of knowledge representation

The suitability and thus the choice of the inference engine depends on the nature of the problem at hand. For example some biological problems are better outlined with a frame system to properly capture the intricate nature of biological processes. For purposes of this problem a rule based system with backward and forward chaining was selected. It was felt that the diagnosis of financial problems was could be well represented with decision rules in a deterministic search tree.

Cost is of course an important item and could involve tradeoffs. For this problem the tool selected was less expensive than other tools available at the time and provided an adequate development environment.

The learning curve of one development environment over another can be a very important consideration. Since the goal of this project was to get a prototype expert system model operational in a short period of time, ease of learning was an important consideration.

Some problems may be rather unique requiring flexibility of representation only found in a custom developed expert system. In this situation the choice may be not to use an expert system shell but instead to use a higher level language such as LISP or PROLOG. For this project a rule based approach available in an expert system shell was sufficient to represent the problem at hand.

There are many possible features to be found on expert system shells, that can facilitate the development process. The range of features available is changing as more tools become available on the market. Some of the features currently offered by various packages include; explanation facilities, screen formatting capabilities, arithmetic functions, access to the operating system environment, interfaces with other programs for passing parameters, flexibility of knowledge representation, transparency of the knowledge base and run-time licensing arrangements.

The tool selected for use in this research project, a rule based shell written in Turbo Pascal called Insight Two Plus, and marketed by Level Five Research (18) was selected for the ease with which a prototype could be developed and tested. Also as pointed out earlier this shell provided a reasonable development environment for a low initial cost. The selection criteria therefore depends on the nature of the problem, the goals of the project, and the preferences of the individual who will be using the tool.

4.4 Conceptualization, Formalization, Implementation and testing

The next stages have been referred to as conceptualization, formalization, implementation and testing (13). The flow characteristics of the problem are carefully outlined and then formalized with the specific expert system tool chosen. The conceptualization and formalization process are the knowledge acquisition phases of the project. They involve construction of decision rules and assembling the data needed to adequately model the problem to be solved. The knowledge acquisition phase for this project is discussed in detail in the next section. The implementation process involves the building of a prototype that is capable of execution and testing.

It is important to emphasize that the development of an expert system as with any decision support system should be looked at as an evolutionary process. As more information is learned about a subject, the knowledge base will be redesigned and the knowledge tree will be reconstructed. Most of the successful expert systems are developed over a period of many years. The prototype to be developed for this research project will be the first stage in a lengthy development process.

4.5 Knowledge Acquisition

The most important stage of the expert system development process is that of knowledge acquisition. The acquiring of the knowledge and the formalization of this knowledge into decision rules is referred to in expert system terminology as knowledge engineering. This is the process whereby the knowledge about the specific problem area is gathered. The knowledge engineering process outlined in most of the literature involves discussions with an expert in the specific problem area. The expert provides the heuristic reasoning and the sequential decisions in the expert system.

Some experts may only be used to validate the reasoning of an existing prototype. Expert opinions can come from a number of experts, some of which may help in designing the scope of the problem as well as recommending additional sources of information. Using more than one expert may be one way of avoiding the representation of only one individual's biases.

Knowledge for this project was selected from extension publications, texts on agricultural finance and from direct discussions with experts. This knowledge base is made up of some simple measures of dairy management and firm growth concepts. It is heuristically tied together with decision rules developed with logical operators.

The knowledge acquisition phase of this project took place in two basic stages. First, a prototype was constructed using the knowledge and experience of this researcher acting as the knowledge engineer and domain expert. This prototype was demonstrated to several domain experts in the area of farm finance and farm management. Using suggestions of these various domain experts through an iterative process, the knowledge base was constructed as it now appears in this research document. Example rules that refer to the following sections can be found in appendix C.

The knowledge base for this problem is partitioned into four categories. The knowledge in these four categories was obtained from a variety of sources that will be discussed as each category is addressed. These categories are :

1) Firm performance assessment and categorization
2) Analysis of selected expense items
3) Analysis of feed and cropping practices
4) Analysis of livestock expenses

The specific source of knowledge and the general nature of the decision rules for each of these categories will be outlined and discussed for each of the knowledge categories in the following pages.

4.5.1 Firm performance assessment and classification

This section of the knowledge base was constructed in two stages. The sources of the knowledge for the first stage of construction came from agricultural finance texts (1). The knowledge was based on simple concepts of firm growth and risk. During the second stage of construction some of the decision rules were changed using the suggestions of loan officers from Farmers Home Administration and Farm Credit Services.

There are two goals of this portion of the knowledge base. The first is to separate firms according to their performance regarding selected financial variables listed below. In this way individualized output can be written that is tailored to the specific circumstances of the farm. This is the reason for the large number of rules in the knowledge base. Each possible combination of the financial variables was represented.

The second goal is to focus on overall credit risk, overall financial position, prediction of short term (2 to 3 years) and long term prospects for financial solvency. The firm is given a rating of good, moderate or poor for each of these four criteria according to the values given for the variables listed below.

The following variables are used in this section of the knowledge base. It was agreed by the loan officers participating in this research that these variables were the most important.

1. owners equity
2. number of balance sheet years analyzed
3. trend in owners equity
4. debt asset ratio
5. interest & rent expenses as a percent of gross income
6. net income
7. withdrawals (outside income minus family withdrawals)
8. trend in asset values

4.5.2 Determination of Individualized Output

Using the above variables the following performance thresholds were obtained during discussions with loan officers with Farm Credit Services (FCS) and Farmers Home Administration (FmHA). In the next section each variable will be discussed separately. This will be followed by an example of how these variables are heuristically tied together in the knowledge base.

1. Owners Equity

In order to avoid discriminating against farms operating on a low capital base the magnitude of owners equity is not considered. If equity is negative the firm was classified as insolvent, the firm is automatically classified as poor in all categories and this portion of the knowledge base execution is terminated. If equity is positive the knowledge base continues to process the case.

A decision rule example is shown below in figure 4.1. This is exactly the way it appears in the knowledge base in Insight Two syntax (18) and is written in object => attribute => value clauses.

The first line is the name of the rule. This is followed by antecedents "continue analysis" and equity < 0. The object is equity, the attribute is less than 0 and the value is farm is insolvent. The goal "solvency trend determined" is proven.

FIGURE 4.1 DECISION RULE EXAMPLE : EQUITY

RULE	Determination of current solvency
IF	Continue analysis
AND	Equity < 0
THEN	The farm has a negative equity
AND	PRINT The farm is technically insolvent
AND	Solvency trend determined

2. Number of balance sheet years analyzed

If only one year of balance sheet information is provided, the knowledge base bypasses analysis of equity trends and instead examines debt asset ratio, net income, withdrawals, interest & rent expenses as a percent of gross income. This limits the analysis to an assessment of risk based on a snapshot of the firms financial position provided by one year of balance sheet information.

If only two years of balance sheet information are provided the expert system performs the same analysis as it would if the firm had three or more years of data. The analysis is prefaced with a cautionary note explaining that the two years under examination should be indicative of the performance of the firm over the last four or more years if the results of the predictions are to be of any use.

To receive full scrutiny, if three or more years of data are provided the expert system examines the firm for the four criteria mentioned above; overall credit risk, overall financial position and assessment of short term (2 to 3 years) and long term prospects for financial solvency.

1 year of information - firm is given only a risk rating
2 years of information - firm is analyzed fully but the analysis is prefaced with a cautionary note.
3 or more years - continue analysis

Figure 4.2 is a decision rule example for this section of the knowledge base. The IF AND clauses are antecedents. The conclusion following the THEN statement is suppressed (user does not see it) and the clause following the PRINT statement is sent to the printer. This clause is prefaced by a DISPLAY key word at the end of the knowledge base. This allows for a whole paragraph of conclusions to be sent to the printer. The object of this rule is YEARS, the attribute is equal to two and the value is "Quality of the data is not very reliable."

FIGURE 4.2 DECISION RULE EXAMPLE : YEARS PROVIDED

```
RULE     Determination of poor data quality
IF       Continue analysis
AND      YEARS = 2
THEN     Data so so
AND      PRINT Quality of the data is not very reliable
AND      Data quality determined
```

3. Trend in owners equity & Trend in Asset Values

An important measure of past performance is whether or not owners equity has been trending up or down or remaining constant. By comparing this measure with the rate of inflation or deflation in asset values, the analyst can determine if equity has been increasing because of the firm's contribution to retained earnings or if the equity increase has been carried by inflation.

asset values decreasing, equity decreasing faster
asset values decreasing, equity decreasing slower
asset values decreasing, equity unchanged
asset values decreasing, equity increasing

asset values increasing, equity values decreasing
asset values increasing, equity unchanged
asset values increasing, equity increasing slower
asset values increasing, equity increasing faster

4. Debt Asset Ratio

After discussion with loan officers the following three thresholds of debt asset ratio were obtained.

low - debt asset ratio less than .40
median - debt asset ratio between .40 and .70
high - debt asset ratio greater than .70

An illustration that combines some of these factors using a search tree representation is shown in figure 4.3.

5. Interest & Rent Expenses as % of Gross Income (INRNGI)

As with criteria number four the following three thresholds of performance were obtained through discussions with loan officers for INRNGI.

low - INRNGI less than .15
median - INRNGI between .15 and .25
high - INRNGI greater than .25

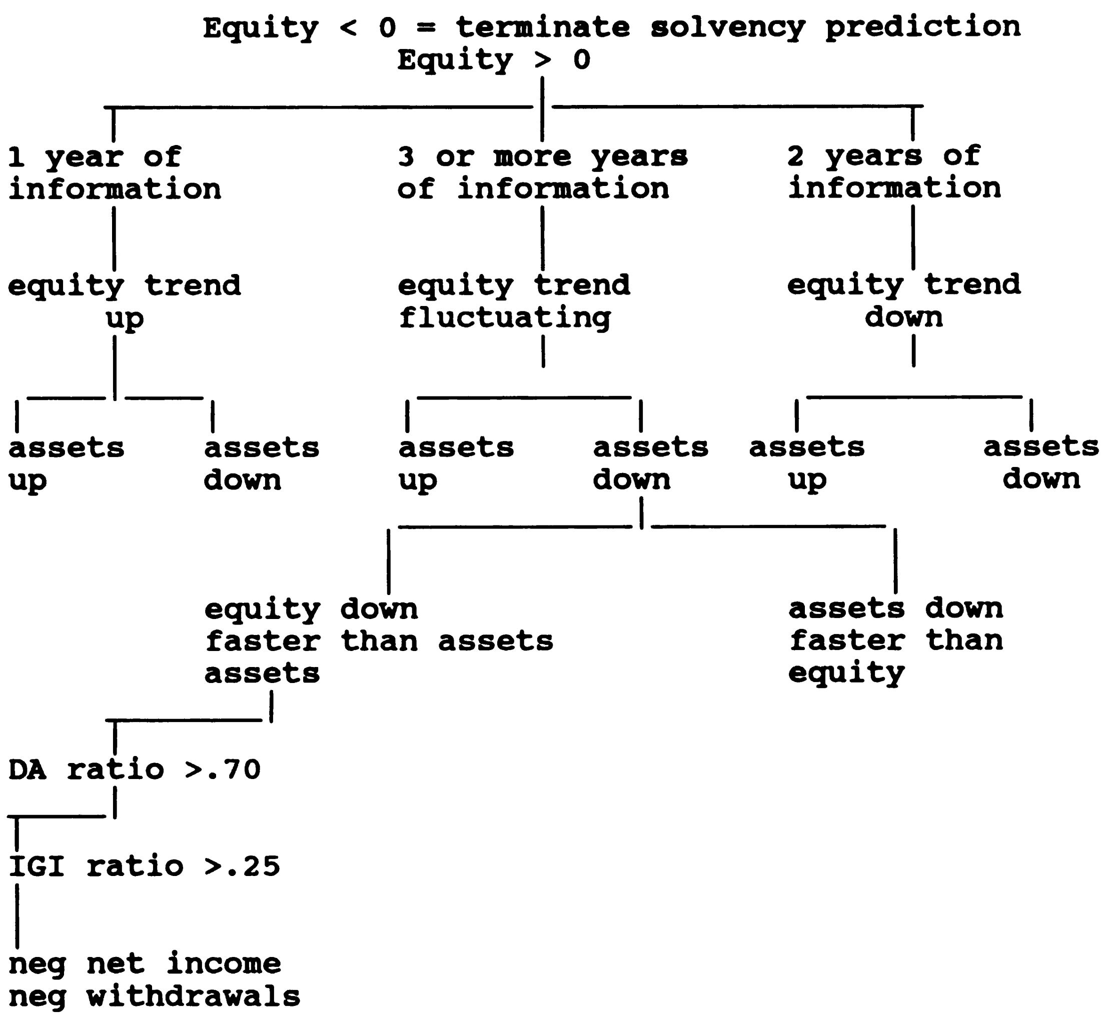
6. Net Income & Withdrawals

The following four thresholds or categories were developed for combining these two criteria:

1. Net income + withdrawals are less than 0.
2. Net income is greater than 0 while withdrawals are less than 0.
3. Net income greater than 0 and withdrawals less than 0 but the absolute value of Netincome is greater than the absolute value of withdrawals.
4. Net income less than 0 and withdrawals greater than 0 but the absolute value of withdrawals is greater than the absolute value of Net income.

A specific example to clarify how all of the above criteria are combined to obtain individualized output is illustrated in the search tree in figure 4.3. This is followed by a decision rule example written in Insight Two syntax in figure 4.4. followed by an example of the output in figure 4.5.

FIGURE 4.3 SEARCH TREE REPRESENTATION FOR FIRM CLASSIFICATION AND SOLVENCY PREDICTION



conclusion:
firm has poor overall position
firm is a high credit risk
prospects of short term solvency poor
prospects of long term solvency poor
solvency trend determined

An individualized assessment of the firms position will also be written based on how the above criteria are combined.

The rule illustrated in figure 4.3 can be rewritten using the notation of set theory or logic as shown below. Using the letters to refer to the clauses in the rule, the illustration below written symbols in set theory says: IF A and (B or C or D) and E and F THEN (G and H) which are contained in the set I.

A /\ B \/ C \/ D /\ E /\ F ==> G /\ H Ë I

The rule as it appears in the knowledge base that reaches this conclusion is shown below in figure 4.4.

FIGURE 4.4 DECISION RULE EXAMPLE : FIRM CLASSIFICATION

	RULE	To see if farm has high debt, high Interest/rent expense
A)	IF	The farm appears to have too much debt
B)	AND	The farm may not be profitable
C)	OR	Operation of farm is eroding net worth
D)	OR	Fluctuating equity may be due to unprofitability
E)	AND	INRNGI >= .25
F)	AND	NETINC + WITH <= 0
G)	THEN	This is in the poorest position
H)	AND	PRINT poorest position
I)	AND	Solvency trend determined

The clause following the IF key word is the conclusion to an earlier rule that puts the farm in the high category for debt asset ratio. The next three antecedents following the AND OR key words are three of the unfavorable combinations of equity trend and inflation. For example the clause "Operation of farm is eroding net worth" is a scenario where equity was trending down while asset values were trending up.

INRNGI is the variable for interest and rent expenses as a percent of gross income, WITH is the variable for outside income less family withdrawals and NETINC is net income. So a farm with debt asset ratio above 70%, an unfavorable trend in equity, interest and rent ratio above 25%, and negative net income plus withdrawals will yield the conclusion "This is the poorest position."

FIGURE 4.5 INDIVIDUALIZED OUTPUT EXAMPLE

DISPLAY Poorest position

This farm has signs of having an unsustainable financial position. High debt asset ratio of [DETAST (4,2)] combined with high interest and rent expenses ratio of [INRNGI (4,2)] indicate high vulnerability to low prices and adverse weather conditions. Recent income statement shows losses of [NETINC (8,2)] and is not supported by outside sources. The farm has provided [YEARS(3,1)] of data with an equity trend of [TREND (5,2)]. If the farm can become profitable there is still an opportunity for improving the firms financial condition.

- Overall position of the farm is poor.
- Farm is a high credit risk
- Prospects for firm survival are poor in short or long term.

The clause "poorest position" located after the key word PRINT will print the clause shown in figure 4.5 for the user. This is an example of how the expert system provides individualized output. All possible combinations of the relevant financial variables are represented in this manner.

All the possible combinations of the above criteria are addressed in the knowledge base. For example if the next firm under analysis was to have all other criteria the same with the exception that INRNGI was between 15% and 25% there would be a different statement written for that firm. In some cases however the output would be so close for two different firms that the same statement is given to both firms in order to conserve disk space.

4.5.3 Firm Classification

Lenders have a variety of ways to classify financial performance criteria. It depends upon the goals of the firm classification process, whether it is for loan pricing or acceptance or rejection of a loan application. The manner in which the farm firms were classified for this research project was somewhat arbitrary. The classification scheme presented here is based almost solely upon the debt asset ratio with the other criteria having a lesser influence.

4.5.3.1 Overall Firm Position

The following three classifications were used for overall firm position. The threshold for debt asset ratio to classify firm position as poor was moved from 65% to 70% after meetings with various experts.

good	-	debt asset ratio <= .40
moderate	-	debt asset ratio between .40 and .70
poor	-	debt asset ratio >= .70

The only exception to this rule occurs when a firm has a debt asset ratio placing it in the extreme categories of good or poor. In this situation if all other criteria are at the opposite extreme the firm will then be moved into the moderate category. For example if the firms debt asset ratio would normally place it in the good category for firm position but all the other criteria are poor, then the firm would be categorized as having a moderate position instead of a good position.

4.5.3.2 Credit Risk

Determination of credit risk uses the same criteria as firm position. For purposes of this assessment overall firm position and determination of credit risk are different ways of saying the same thing. For no cases will the knowledge base classify a firm one way for firm position and another for credit risk.

4.5.3.3 Determination of Solvency Trend

For the purposes of this assessment the definition of financial insolvency is the point where the firm reaches a negative equity. Prediction of financial solvency is divided into short term (2 to 3 years) and long term. In most cases a firm classified as good, poor or moderate in the previous two categories will be classified the same in these two categories. The following are the exceptions;

1. Firm is classified as moderate previously but equity has been trending down not due only to inflation. In this case the firm will be given a moderate for short term and poor for long term.
2. Firm is classified as good for overall position and credit risk but equity has been trending down not due only to inflation. The firm will be given a good for short term and moderate for long term.
3. Firm has a high debt asset ratio normally putting it into the poor category but all other criteria are favorable. That is firm has positive income, equity is trending up and interest and rent expenses are low. In this case the knowledge base will categorize the firm as moderate for firm position as well as long term solvency.

4.5.4 Analysis of Telfarm factors

This portion of the knowledge base examines the four largest expense items on the income statement of the farm. Using the information from Michigan State Universities 1984 Telfarm Business Analysis summary (23) illustrated in table 4.1. Each of the four expense items are compared to the Telfarm average for the farms of similar size category.

TABLE 4.1 SELECTED TELFARM EXPENSES AVERAGE FOR DAIRY FARMS, 1984

# Cows	fertilizer	fuel	repairs	labor
less than 50	8322	4232	7459	5206
50 to 75	16664	6815	12439	111153
75 to 100	16980	8003	13317	15104
over 100	32954	13445	26570	39611

The structure of the decision tree used to represent the knowledge illustrated in table 4.1 is shown in figure 4.6. The recursive nature of the knowledge base is highlighted in this diagram. The conclusions to the first rule for fertilizer expenses are antecedents for the rule that follows. Whether or not fertilizer is above Telfarm averages or below, either of these conclusions will activate the next rule.

FIGURE 4.6 SEARCH TREE REPRESENTATION OF ONE SECTION OF THE KNOWLEDGE BASE

GOAL : TELFARM FACTORS INVESTIGATED

less than 50 cows	between 50 and 75	between 75 and 100	more than 100 cows
|	|	|	|
repair expense evaluation	repair expense evaluation	repair expense evaluation	repair expense evaluation
|	|	|	|
fuel expense evaluation	fuel expense evaluation	fuel expense evaluation	fuel expense evaluation
|	|	|	|
fertilizer expense evaluation	fertilizer expense evaluation	fertilizer expense evaluation	fertilizer expense evaluation
|	|	|	|
hired labor expense evaluation	hired labor expense evaluation	hired labor expense evaluation	hired labor expense evaluation

telfarm factors investigated

Figure 4.7 is an example of a decision rule for the search tree representing Telfarm factors. Notice how the rule illustrates the recursive nature of the decision tree. The antecedent for this rule requires a previous determination of high or low on repair expenses. The variable LOWG calculates by what percentage fuel expenses are below Telfarm average for this size of farm.

FIGURE 4.7 DECISION RULE EXAMPLE : ANALYSIS OF TELFARM FACTORS

RULE	To examine fuel and oil expenses below 50 cows
IF	Repair expenses are higher than TelFarm averages
OR	Repair expenses are below TelFarm average
AND	COWS <= 50
AND	FUEL < 4300
AND	LOWG := ((FUEL)/4300)*100
THEN	Fuel expenses are lower than TelFarm averages
AND	PRINT Low fuel

The average Telfarm factors in table 4.1 had to be adjusted to fit the quality of the information and the level of detail found in the case farms. Fertilizer expense averages include not only fertilizer and lime but also chemicals since most of the farms examined did not list these as separate items on their income statements. Fuel expense averages include oil and grease. Repair expense averages represent those for both machinery and buildings since most income statements used combined them. Labor expense represents only hired labor. The operator's labor is used to evaluate overall farm efficiency.

After examination of these various expenses, the knowledge base states whether or not the expense is higher or lower than the average and by what percent. This gives the farm manager a flag whereby they can begin examination as to why an expense item may be high for that year and how it may be adjusted.

An important point worth noting is that the highlighting of a particular expense item as above or below the Telfarm average does not necessarily indicate that there is a problem. There are a number of reasons why an expense item may deviate substantially from the average. The item may include prepaid expenses, other expenses may be combined with this expense on the income statement, other enterprises may be included on the income statement or the specific conditions due to technology for that particular farm may merit an above average dollar outlay for that particular expense. It is up to the manager to uncover the reasons for a very high or very low expense in a given year. Most specialists say that 25 percent above or below average should be cause for concern.

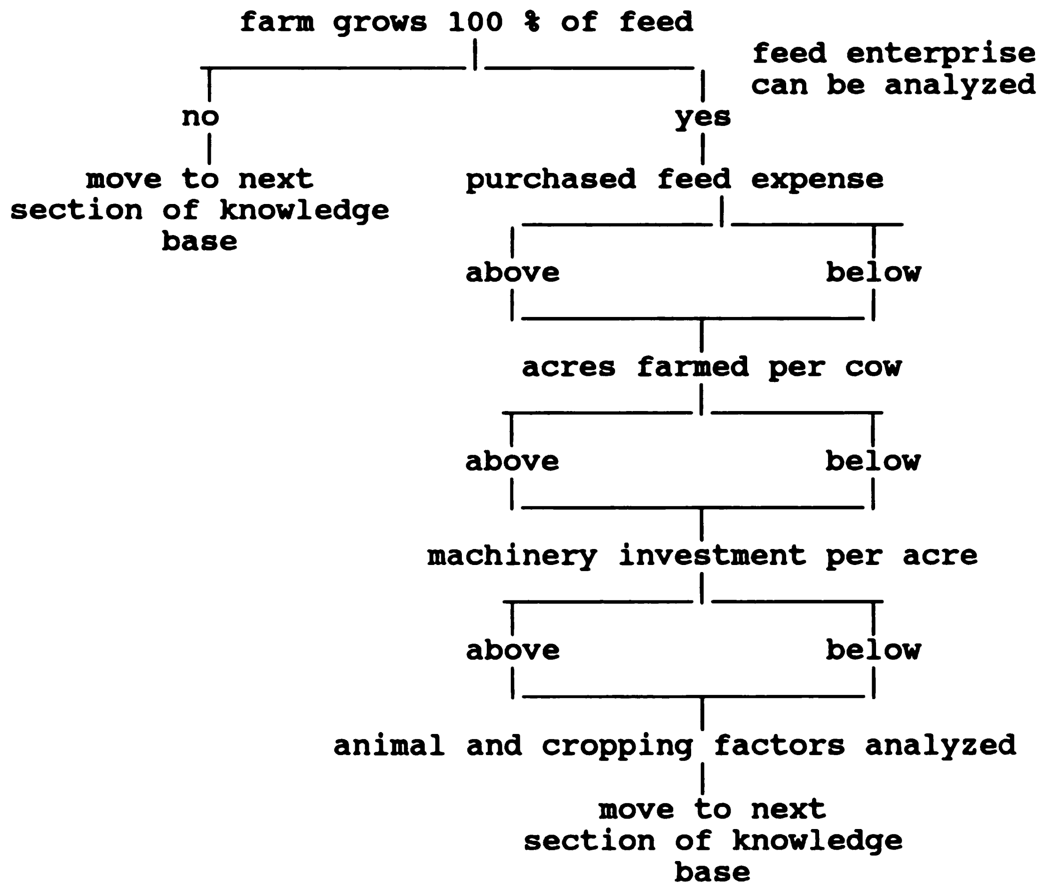
4.5.5 Analysis of Management Factors : Animal and cropping practices

The knowledge in this section was taken mostly from a Michigan State University Extension publication developed by Shaltry and Hlubic (28). In this publication they have outlined several financial standards for dairy operations. The following is a discussion of the standards taken from this publication that have been included in the knowledge base of the program:

- Purchased feed expenses between $2.50 and $2.65 per hundredweight of milk sold
- acres farmed per cow between 3.5 and 5 acres per cow
- machinery investment per acre of less than 250 dollars

These factors assume that the farm has limited cash crop operations and the goal of the manager is to grow at least 100 percent of the feed. Thus the feed expenditures represent only feed supplements and no concentrates or forage. Williams (33) points out that feed expenditures should be expressed on a per hundredweight of milked shipped basis to capture the increase or decrease of efficiency of feeding. The manager must be sure that increases in feed costs per cow result in lower feed cost per hundredweight through increased production per cow.

FIGURE 4.8 SEARCH TREE REPRESENTATION FOR MANAGEMENT FACTORS : ANALYSIS OF ANIMAL AND CROPPING PRACTICES



The economics behind these standards are simple. Any producer spending below the range shown for feed expenditures may not be realizing the full potential returns from their dairy enterprise. Any producer above this range could be said to be spending more on feed supplements than realized returns from that feed.

Before these three criteria are analyzed, the knowledge base asks the farm being analyzed is growing all feed needed by the animals. If they are not, then these three criteria are not analyzed. The search tree for this section of the knowledge base is illustrated in figure 4.8.

FIGURE 4.9 DECISION RULE EXAMPLE : ANALYSIS OF ANIMAL AND CROPPING PRACTICES

```
RULE     To see if the farm is spending too much on feed
IF       Feed enterprises can be analyzed
AND      PURFD > 2.6
THEN     Feed expense is high
AND      PRINT  high feed
```

The first measure looking at purchased feed costs helps the user detect possible problems with the feed ration or cropping practices. For example, a farm that grows all its feed and spends more than the given standard on purchased feeds may have a poor ration or poor quality forages. Figure 4.9 is an example of a decision rule in the knowledge base that makes a determination of high purchased feed expense compared to the standard.

The second and third measures attempt to indicate if the farm may be overinvested in land and machinery. After cash crop acreage is subtracted off in the spread sheet, the program attempts to use a standard to provide signals to the manager for an over investment in land.

Machinery investment is examined in the same manner. However, the manager is cautioned if there are cash crops on the farm due to the fact that machinery needs vary with enterprise type.

A study at Cornell University (3) showed that farms with higher pounds of milk sold per FTE had higher management incomes per operator. To analyze labor efficiency for a dairy farm, Shaltry and Hlubic also used Pounds of milk sold per FTE (full time equivalent). Standards for this variable depend on the type of animal housing and whether or not the farm grows any feed as shown below :

- over 500,000 pounds per FTE for stanchion barns
- over 600,000 pounds per FTE for parlor systems
- over 850,000 pounds per FTE if no crops are grown

As noted above, labor efficiency depends on type of housing. If type of housing is not known then the knowledge base does not attempt to assess the efficiency of labor.

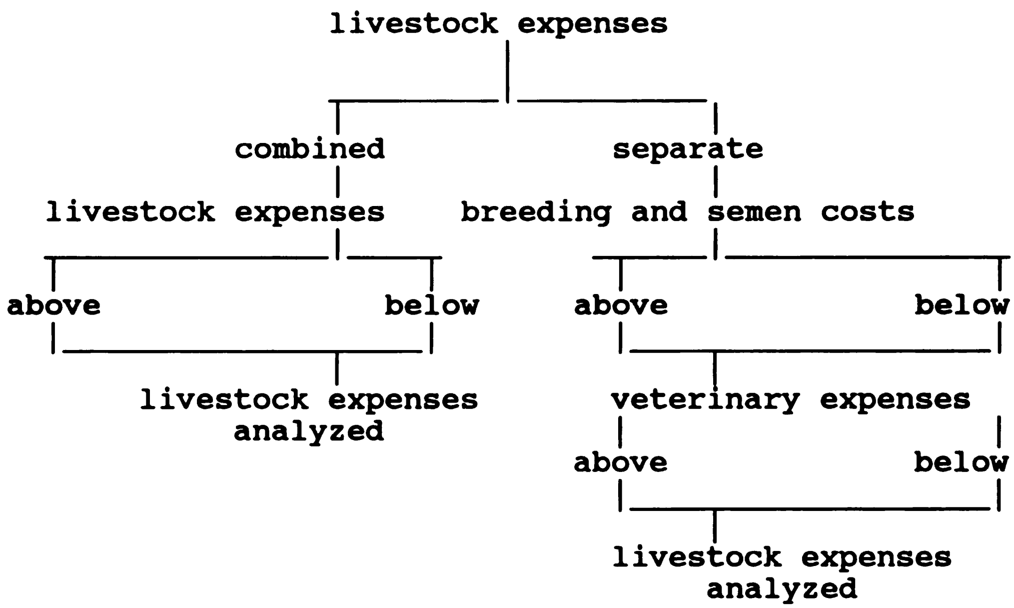
If a farm is found to be shipping less milk per full time equivalent then any of these standards, it may be a signal to a manager that they may have too many or poor efficiency in their workers. However a farm with cash crops will have lower pounds of milk shipped because they are using labor for other productive enterprises. These standards could then be adjusted for an individual operator by referring to the Telplan budgets (22) and determining the normal number of labor hours required for a given cash crop enterprise. Divide the total number of hours worked on the enterprise by 3,000 since each 3,000 hours represents one FTE. Subtract these FTE's from the total FTE on the farm. This may give the manager a better picture of the efficiency of labor for the dairy enterprise.

The next two standards analyzed are veterinary and breeding costs. These standards were also developed by Hlubic and Shaltry (28).

- vet expense between .30 and .35 dollars per hundredweight of milk sold
- breeding and semen costs between .16 and .21 dollars per hundredweight of milk sold

Since most farms account for livestock expenses as one lump expense, and do not divide them up into breeding and veterinary expenses the knowledge base then gives the user the option to analyze these expenses items together or separately. Figure 4.10 illustrates the search tree for his small section of the knowledge base.

FIGURE 4.10 SEARCH TREE REPRESENTATION : LIVESTOCK EXPENSES



These standards were drawn up based on observations of MSU Telfarm data. The researchers did not derive an aggregate production function for all of the cows on TelFarm. The interpretation of these standards is similar to that of the standards developed for feed expenditures per CWT of milk sold. That is if any producer is spending below the acceptable range they may not be realizing the full potential returns to livestock expenditures. Any producer above this range then may be spending more on livestock expenditures than realized returns.

More research is needed in the area of dairy economics. Feeding and herd health practices are areas of the animal production process that need more study in order to better determine more cost effective strategies of herd management.

CHAPTER V

EXPERT SYSTEM ANALYSIS AND RESULTS

5.1 Introduction

The farm data used for the execution and testing of the expert system prototype was obtained from the files of Farmers Home Administration and Farm Credit Services.

In order to comply with University regulations there were steps taken to assure anonymity of the participating farms. Farm cases that came from Farm Credit Services (FCS) were chosen by the loan officers with the names removed from the financial statements The farm owners from Farmers Home Administration (FmHA) were sent a letter signed by the FmHA county supervisor explaining the research project and containing a consent form. The county supervisor selected the farms to be sent this form. The farmers then had to sign this consent form acknowledging their participation in the research project and mail it back to Michigan State University. In this way only farmers agreeing to participate in the research were analyzed.

5.2 Case Farm Data

Five years of balance sheet information were gathered for the 1980 to 1984 period. The purpose for choosing this period is to be able to assess the predictive capabilities of the expert system prototype. This will be done by allowing for the comparison of the actual position of the farm operation as of 12/31/86 with the projections obtained from the knowledge base which uses financial data from 1980 to 1984. It may be of interest to see if the knowledge base may have predicted the liquidation of a farm having gone out of business since the end of 1984.

The income statement year chosen for analysis by the knowledge base is 1984. This year was chosen because it corresponds with the 1984 Telfarm business analysis summary which was used to build the knowledge base. This was the most recent Telfarm data available at the time this study began. It was also chosen because it was the income statement year for which the highest number of farm cases had data and it corresponds to the base period analyzed in the balance sheets.

5.2.1 Limitations of the Data

The data used in this research came from the lender and not the farmer. It was therefore limited to income statement and balance sheet information only. The analysis is thus bounded by the level of detail provided by a total farm accounting approach. A more in depth analysis could be performed with cost accounting information or partial enterprise budgets that may at times be available using records kept on the farm. The analysis performed by this expert system should therefore be looked at as a tool for signaling possible problem areas of the business. To assess the cause of these signals would require more detailed analysis using data obtained on the farm or through detailed consultation with the farm manager.

Most farms keep one set of books where all transactions are recorded on a cash basis only. For tax purposes this allows a farm manager to reduce taxable income in a given year by prepaying expenses for the following year (12). This is referred to as cash accounting. Often times there is no attempt to distinguish between the costs associated with earnings in different years with the lenders records. Because of this accounting method, the knowledge base may incorrectly highlight a given expense item as over the TelFarm average when in fact if the prepaid expenses were subtracted off would likely be under the Telfarm average. Although the financial statements used for this project allow for the subtraction of prepaid expenses, many income statements found in the loan record files had no entries for prepaid expenses.

Some farm business were not used for this research because a balance sheet could not be constructed with the information in the case file. Of the farms chosen for analysis, there were five farms that had only one year of balance sheet information available in their case file. These farms were only chosen after consultation with the loan officer to assure that the data was representative of what has been occurring on the farm. There is a branch in the decision tree of the knowledge base that will attempt to analyze one year of balance sheet information. However the analysis given by the knowledge base is prefaced with a cautionary note and only guarded conclusions about the business are drawn.

Six of the farms chosen for analysis had only two years of balance sheet information. The knowledge base processes these cases as if they have three or more years of information, however the analysis includes a paragraph that warns user to interpret the analysis with caution.

There were also three case farms for which there was not a 1984 income statement. The income statements came from the years 1983 for one farm and 1985 and 1982 for the other two farms. It was felt that since farm expenses have not significantly changed during this period that the analysis could still be performed on these farms with 1984 Telfarm averages.

The limitations of the data therefore prevent certain comparisons between farms. For example farms only providing two years of balance sheet data did not always provide the same two years. This prevents direct comparison between the performance of any two farms providing the same number of years of information. The knowledge base avoids such comparisons by making an assessment of firm position based on set criteria.

In it's present form the knowledge base will acknowledge how many years of data were provided and each analysis is prefaced with a cautionary note which depends on the number of years of information provided.

5.2.2 Farmers Home Administration Verses Farm Credit Services

The farmers from Farm Credit Services were not aware of their participation in the research. The farm owners from Farmers Home Administration (FmHA) however, had to sign the consent form so that these farmers from FmHA had full knowledge of their participation in the research. The quality of records and the financial position supplied by a willing research participant is likely to be different from one who participates without prior knowledge. Thus any comparisons of financial performance between FmHA and FCS borrowers are likely to reflect this.

In general the records from FmHA were found to have much less information than those of FCS. The case farms agreeing to participate in the research from FmHA were often new borrowers and therefore several years of financial information were not available on them. Another reason for the lack of financial information at FmHA is due to the fact that many farms examined had only emergency loans or real estate loans with the agency. Short term or yearly operating loans for these managers was obtained elsewhere. Thus FmHA did not feel the need to collect updated financial information every year as long as the farm was making payments on their accounts. FCS on the other hand, makes yearly operating loans to most of the farms studied in this project thus explaining the difference in the level of detail of the information supplied by the two agencies.

5.2.3 Farm Asset Valuation Problem

The recorded value of the assets listed on the financial statement was found to conflict with the opinion of the loan officer and USDA data for two of the case farms. As pointed out in the introductory chapter of this research document, farmers tend to value their assets higher than fair market value. For these two case farms the value listed for real estate was higher than fair market value. Two possible adjustments were devised to circumvent this problem.

Real estate values have dropped in Michigan at the rate of 5 per cent between 1981 and 1984 (33). The two adjustments considered to bring real estate values in line with actual market values were: 1) If only one years balance sheet data was available and the loan officer disagreed with the value shown, then the real estate was adjusted on a per acre basis according to Michigan statistics for the price of land for that year. 2) If several years of information was available and there was a difference in opinions on real estate value, it was decided that the real estate should be adjusted according to the percent drop indicated by USDA for land during that period. Table 5.1 shows that there was no significant drop between the 1980 and 1984 period. It appears that the loan officers were considering todays real estate markets and not those of 1984. Only two received an adjustment for real estate values on their balance sheets (case farms V and W). The factors used in this consideration are shown in table 5.1.

Table 5.1 Farm Real Estate Values: Dollars Per Acre State of Michigan

Year	1980	1981	1982	1983	1984
Price/ acre	1111	1289	1278	1223	1223

Source : Outlook and Situation Summary, USDA, ERS, April 9, 1986

5.3 Data Preparation

An electronic spreadsheet marketed by Lotus (19) and used on a microcomputer was used to collect the financial information and prepare it for analysis on the expert system prototype. The spreadsheet approach was found to have the flexibility needed for storing financial information from the variety of forms presented in the case files however this method was very labor intensive.

Below is a list of the variables calculated with the spreadsheet that were used by the expert system. These variables are calculated using selected preliminary information, balance sheets and a 1984 income statement.

The financial information for each of the case farms used for this research was manually entered into the spreadsheet. A sample of this base information can be found for two case farms in appendix A.

FIGURE 5.1 FINANCIAL VARIABLES ANALYZED BY THE EXPERT SYSTEM

EQUITY - current equity in dollars as of the last year of the analysis period.

TREND IN EQUITY - per cent increase or decrease in equity from the first year of balance sheet information supplied to the last.

DEBT/ASSET RATIO - total liabilities divided by total assets as of the last year of the analysis period.

INTEREST,RENT/GROSS INCOME - 1984 interest and rent expense expressed as a percent of gross income.

FEED COSTS/CWT MILK SOLD - 1984 feed costs in dollars per hundredweight of milk sold.

VET EXPENSES/CWT MILK - 1984 veterinary expenses in dollars per hundredweight of milk sold.

BREEDING EXPENSES/CWT MILK - 1984 breeding and semen expenses in dollars per hundredweight of milk sold.

LIVESTOCK COSTS/CWT MILK - veterinary and breeding costs combined in dollars per hundredweight of milk sold.

MACH INVEST PER ACRE FARMED - total 1984 market value of machinery divided by the number of acres farmed.

ACRES FARMED PER COW - acres owned plus acres rented minus cash crop acres divided by the number cows for 1984.

1984 NET INCOME - gross farm income less operating expenses, depreciation, interest, inventory changes and taxes.

1984 WITHDRAWALS - off farm income minus family withdrawals

1984 NUMBER OF COWS - total number of milking cows not counting replacements.

LBS MILK SHIP / FTE PER YR - total pounds of milk shipped divided by the number of full time worker equivalents out on the farm.

1984 REPAIR EXPENSES - total machinery and building repair expenses

1984 FUEL EXPENSE - total gas fuel and oil expense

1984 FERTILIZER EXPENSE - total fertilizer and chemical expenses

1984 HIRED LABOR COSTS - dollars spent on hired labor

NUMBER OF YEARS - the number of years of balance sheet information analyzed.

The values for these variables as calculated on the spreadsheet for each of the case farms are located in appendix A.

5.4 Case Farm Analysis

A total of twenty seven cases were analyzed with the expert system model. Twenty of these farms came from the files of Farm Credit Services. The other seven farms were obtained from the files of Farmers Home Administration. Sixteen farms had three or more years of financial data, six farms provided only two years of data and five farms had just one year of data.

5.5 Financial Analysis with Spreadsheet and Expert System

The spreadsheet was designed to write the output variables illustrated in figure 5.1 to a file in ASCII (American Standard Code for Information Interchange) format and stored on a floppy or hard disk. This ASCII file is then read by the knowledge base of the expert system. This knowledge base, made up of 243 decision rules connected by logical operators (if, then, and, else, or) was developed on an expert system shell marketed by Level Five Research.

The financial analysis carried out with spreadsheet and expert system takes place in two stages. First, the variables listed in figure 5.1 are calculated on the spreadsheet template after the relevant income statement and balance sheet information are keyed in. This is performed using a micro computer capable of working in the MSDOS environment. Using a specially designed function (macro) from the spreadsheet (19), the variables are written to a floppy or hard disk in ASCII format.

The second stage of the analysis begins by copying the ASCII file to the disk containing the expert system knowledge base if is not already there. Once this is completed the user activates the expert system. The first goal of the expert system is to read in the variables calculated on the spreadsheet. After these variables are read in, they are then analyzed by a series of decision rules.

Each goal is proven one at a time by the expert system until the final goal is achieved. As the expert system works through these goals various facts (shown in figure 5.2) are obtained interactively from the user. Any question asked of the user depends upon which goal the knowledge base is working on.

FIGURE 5.2 Interactive Information Obtained From the User by The Expert System

Are livestock expenses separate or combined?
Is the goal of the farm to grow 100 % of the feed for the dairy cows?
If farm does not grow 100% of it's feed, does the farm purchase 100% of the feed?
Are asset values rising or falling?
Are asset values falling at a higher or lower rate than owners equity?

As each goal in the knowledge base is proven, the conclusions reached are written to the printer so that the user can have a hard copy of the output. The conclusions from the expert system for a sample case farm can be found in appendix B.

5.5.1 Individualized Output

The rules in the knowledge base are constructed so as to provide unique conclusions for each farm according to the specific circumstances indicated by their financial information. In order to provide conclusions in this manner, a large and complex knowledge base is required. All possible variable combinations were addressed as outlined in section 4.5.2.

As mentioned above the individualized conclusions contain a cautionary note based on the number of years of data provided. Next there is an analysis of management factors and Telfarm factors. Lastly based on the combination of financial variables an individualized financial summary is written. Included with this last section are the assessments of firm position, credit risk, short and long term solvency (refer to appendix B).

5.5.2 Summary of Expert System Conclusions

The conclusions from the knowledge base are presented in Table 5.2 through table 5.4 for each of the twenty seven case farms. Each table represents the conclusions from a different portion of the knowledge base and will be discussed separately in the following sections.

Table 5.2 Expert System Conclusions : Firm Classification

CASE	OVERALL POSITION	CREDIT RISK	SHORT TERM SOLVENCY	LONG TERM SOLVENCY
A	good	good	good	moderate
B	moderate	moderate	moderate	moderate
C	moderate	moderate	moderate	poor
D	moderate	moderate	moderate	poor
E	good	good	good	moderate
F	poor	poor	poor	poor
G	moderate	moderate	moderate	poor
H	moderate	moderate	moderate	poor
I	good	good	good	good
J	moderate	moderate	moderate	moderate
K	good	good	good	good
L	moderate	moderate	moderate	moderate
M	moderate	moderate	moderate	moderate
N	good	good	good	good
O	moderate	moderate	moderate	moderate
P	moderate	moderate	moderate	moderate
Q	good	good	good	good
R	moderate	moderate	moderate	moderate
S			poor	
T	moderate	moderate	moderate	moderate
U			moderate	
V			poor	
W			poor	
X			poor	
Y	moderate	moderate	moderate	moderate
Z	poor	poor	poor	poor
ZA	moderate	moderate	moderate	poor

5.5.2.1 Firm Classification

Table 5.2 presents the conclusions from the firm classification portion of the knowledge base for the twenty seven case farms. Note that of the twenty two farms supplying two or more years of data, a total of six farms were found to have a good financial position. Fourteen farms were in the moderate category and two were in the poor category. Of the five farms that provided only one year of data, four were given a risk rating of poor and one was given a risk rating of moderate. Since all the farms supplying one year of data were provided by FmHA, the lender of last resort, it is understandable that the majority of these farms would be given a poor rating.

The expert system arrived at these conclusions using simple decision rules written in object => attribute => value (OAV) triplets. These OAV's are connected by logical operators (such as if and then). Example rules provided in appendix D are an exact duplicate of those found in the knowledge base used for this research. These rules are supplemented with explanatory notes to facilitate understanding of the flow and logic of the rules.

5.5.2.2 Selected Telfarm Expenses

Table 5.3 presents the conclusions for the twenty seven case farms. A sample of rules in the knowledge base that arrive at these conclusions can be found in appendix C. The blanks in the table indicate that no data was supplied for that expense item. In general, very few farms were found to be on the high side for any of the expense categories. Of the twenty seven farms only eight had high fertilizer expenses, three had high repair expenses, five had high fuel expenses and only four farms were found to have high hired labor expenses. The remaining farms were divided fairly evenly between low expenses and moderate (referred to as OK) expenses.

Table 5.3 Expert System Conclusions : Analysis of Tel Farm Factors. All Farms.

CASE	FERTILIZER	REPAIRS	FUEL	HIRED LABOR
A	LOW	OK	OK	HIGH
B	HIGH	OK	LOW	LOW
C	LOW	LOW	LOW	LOW
D	LOW	OK	OK	LOW
E	LOW	OK	OK	LOW
F	LOW	LOW	LOW	LOW
G	LOW	LOW	LOW	LOW
H	OK	HIGH	HIGH	OK
I	LOW	HIGH	OK	HIGH
J	OK	OK	OK	HIGH
K	LOW	LOW	LOW	OK
L	HIGH	OK	HIGH	LOW
M	OK	OK	OK	OK
N	OK	LOW	LOW	LOW
O	LOW	LOW	LOW	LOW
P	HIGH	OK	OK	OK

Table 5.3 Expert System Conclusions : Analysis of Tel Farm Factors Continued. All Farms.

CASE	FERTILIZER	REPAIRS	FUEL	HIRED LABOR
Q	OK	LOW	OK	OK
R	LOW	LOW	LOW	LOW
S	LOW		HIGH	OK
T	LOW		OK	HIGH
U	HIGH	LOW	LOW	OK
V	HIGH	OK	HIGH	LOW
W	HIGH	HIGH	OK	LOW
X	LOW	LOW	LOW	LOW
Y	HIGH	OK	HIGH	LOW
Z	LOW	OK	LOW	LOW
ZA	HIGH	OK	OK	OK

Comparison of the results illustrated in table 5.3 with those in table 5.2 does not show a clear relationship between high or low expenses and good or poor financial performance. This is possibly due to the fact that some of the expense items used in the analysis may contain prepaid expenses. A high expense may include prepaid expenditures for next year occurring in this year or a low expense may be the result of inventory carryover from the previous year. Also as mentioned above there are three farms listed that supplied information from different years. This prevents any definite relationships to be drawn between their performance and a high or low indication for an expense item.

Another reason why there may not appear to be any clear relationship between expenses and current financial position is that the financial position of a farm today is the cumulative result of the farm operating in previous years. The impact of the farms current operating results is only partly responsible for the farms current financial position. However, a farm having a high debt/asset ratio and thus a poor financial position may have consistently low expenses along with acceptable management criteria. A farm in such a position is likely run by a good manager which may merit an upgrading of the firms position or credit risk.

Lastly a reason why the analysis should be looked at as a signal to a manager and not conclusive evidence of a high or low expense is due to the variety of crop enterprise mixes likely to be found on dairy farms. These often include some cash crops, meaning that a high or low expense may be the result of a different enterprise mix and may not indicate good or bad performance.

These are some of the reasons why this section of the analysis should be looked at as a tool for highlighting possible problem areas in the business and not a definite conclusion regarding a particular expense.

5.5.2.3 Analysis of Management Factors

Table 5.4 presents the conclusions for the twenty seven case farms. To examine a sample of rules from the knowledge base that arrive at these conclusions refer to appendix C. The blanks in the table indicate that no data was supplied for that management factor. The analysis of these management factors shows different results than those of the Telfarm factors.

Table 5.4 EXPERT SYSTEM CONCLUSIONS: ANALYSIS OF MANAGEMENT FACTORS

CASE	ACRE/COW	MACH/ACRE	PURCHASED FEED	LABOR EFFIC.	LVSTK. EXP.
A	OK	HIGH	LOW	LOW	LOW
B	HIGH	HIGH	HIGH	LOW	LOW
C	OK	OK	LOW	LOW	LOW
D	OK	OK	HIGH	LOW	LOW
E	HIGH	LOW	LOW	LOW	OK
F	OK		LOW	LOW	LOW
G	OK	OK	HIGH	LOW	LOW
H	HIGH	OK	HIGH	OK	OK
I	HIGH	OK	HIGH	LOW	LOW
J	OK	HIGH	LOW	LOW	HIGH
K	OK	OK	OK	OK	LOW
L	OK	HIGH	OK	LOW	LOW
M	OK	OK	LOW	OK	LOW
N	OK		LOW	LOW	OK
O					
P	OK	OK	OK	LOW	LOW
Q	OK	HIGH	LOW	HIGH	LOW
R	OK	HIGH	LOW	OK	LOW
S	OK		LOW	OK	
T	HIGH		LOW	LOW	
U	HIGH	OK	HIGH	LOW	LOW
V	HIGH	OK	LOW	LOW	HIGH
W	HIGH	HIGH	HIGH	LOW	LOW
X	OK	LOW	HIGH	LOW	OK
Y	OK	HIGH	LOW	LOW	OK
Z	OK	OK	LOW	OK	LOW
ZA	OK	HIGH	LOW	LOW	LOW

As with the analysis of the Telfarm factors very few farms were found to be on the high side for livestock expense per hundredweight of milk shipped with only two out of the twenty seven. The twenty seven farms were divided fairy evenly between high and low for acres per cow and machinery investment per acre. A majority of the farms (20 out of 27) have low labor efficiency and the majority (16 out of 27) also have low purchased feed expenditures per hundredweight of milk shipped. The low labor efficiency may be an indication of too many workers on the farm. The low expenditures on feed may indicate a need for an improvement in the dairy ration.

The data used by Hlubic and Shaltry (28) to develop these standards came from 1983 Telfarm records while the income statement year analyzed by the expert system was 1984. The experts interviewed thought that this should have little influence on the outcome of the analysis because these management criteria have stayed relatively the same. This appears to hold true due to the relatively small change in farm expenditures between 1983 and 1984.

5.6 Expert System Test For Agreement

An expert system is a model of decisions made by experts. A comparison of actual decisions of experts with those of the expert system would be of interest. In order to perform this test, three loan officers were interviewed and presented the same variables calculated on the spreadsheet that are read in to the expert system. The variables used by the expert system for this portion of the analysis are equity, percentage increase or decrease in equity over the analysis period, net income, family withdrawals, outside income, debt/asset ratio and interest and rent expenses expressed as a percent of gross income. These were the same variables used by the experts that were interviewed with a few exceptions that will be discussed later.

The variables for each case farm as presented to the loan officers are located in appendix A. Using only these variables the loan officers assessed overall position, credit risk, likelihood of short term solvency and likelihood of long term solvency and gave a rating of good moderate or poor, the same decisions illustrated in table 5.2. The responses of the expert system and three loan officers are illustrated in tables D.1 through D.4 of appendix D.

Table 5.5 is a comparison of the agreement between the expert system and the three loan officers. Each number represents the percentage of cases where the decisions of one expert matched all of those of another. For example the expert system agreed with loan officer number one on 73% of the decisions whereas loan officer number two agreed with loan officer number one on only 67% of the decisions. This means that out of the total of 93 decisions possible, loan officer number one made only 25 decisions that were different from that of the expert system while loan officer number two disagreed with loan officer number one on 31 out of the total 93 decisions.

The results indicate that loan officer number one and the expert system both had the most amount of agreement with the other loan officers whereas loan officer number two showed the least amount of agreement while loan officer number three showed the next least amount of agreement. It is interesting to note that loan officer number three had only two years of working experience while loan officer number one and two had ten and fifteen years of experience respectively.

Table 5.5 Measure of Agreement among expert system and loan officers. All decisions.

	expert system	loan officer#1	loan officer#2	loan officer#3
expert system	100%	73%	69%	69%
loan officer#1	73%	100%	67%	71%
loan officer#2	69%	67%	100%	68%
loan officer#3	69%	71%	68%	100%

5.6.1 Firm Position

When the decisions are broken down by category some interesting points are brought to light. Table 5.6 examines the results of the test for assessing overall firm position. The data indicates that the expert system and loan officer number one had the most amount of agreement whereas loan officer number three showed the least amount of agreement.

To arrive at this conclusion the knowledge base used the debt asset ratio as the sole criteria to assess firm position. Because this variable is so widely used by experts to obtain a quick assessment of a business, it follows that the level of agreement between the loan officers and the expert system would be relatively high here.

Table 5.6 Percentage of Agreement between Experts on Overall Firm Position

	expert system	loan officer#1	loan officer#2	loan officer#3
expert system	100%	73%	64%	68%
loan officer#1	73%	100%	73%	59%
loan officer#2	64%	73%	100%	59%
loan officer#3	68%	59%	59%	100%

5.6.2 Credit Risk

The next decision shows the expert system performing less favorable in agreeing with the decisions of the other experts. For this decision loan officer number one and two show the greatest amount of agreement while the expert system and loan officer number three show the next lowest and the lowest respectively.

The poorer performance of the expert system is likely due to criteria used to reach the decision. The expert system used no different criteria between this decision and the decision regarding firm position. When asked later about their decisions, two of the experts equated credit risk with repayment ability which is tied directly to liquidity or net income. They indicated that net income had a stronger influence on their decisions for this criteria although they still considered debt asset ratio. The expert system however directly equated credit risk with firm position.

The cause for the lack of agreement may be due to the unclear definition of credit risk at the time the experts were interviewed. Since there is no difference in the criteria used by the expert system to assess credit risk and firm position then perhaps the definition of firm position should be expanded to include credit risk.

Table 5.7 Percentage of Agreement between Experts on Credit Risk

	expert system	loan officer#1	loan officer#2	loan officer#3
expert system	100%	68%	68%	50%
loan officer#1	68%	100%	64%	64%
loan officer#2	68%	64%	100%	55%
loan officer#3	50%	64%	55%	100%

5.6.3 Short Term Solvency

The assessment of short term solvency is another decision where the expert system shows a lesser degree of agreement with the other decision makers. Loan officer number three shows the highest amount of agreement with the other decision makers on this decision while loan officer one shows the next highest. The expert system and loan officer number two show the next lowest and the lowest amount of agreement respectively.

The cause for the poorer performance of the expert system is likely due to the same reasons as those for assessing credit risk. The criteria used by the expert system for assessing short term solvency, credit risk and firm position are exactly the same. On the other hand loan officers were looking at equity trend, interest and rent expenses and net income. It also appears that the experts may not have been comfortable with the concept of short term solvency.

It appears that the definition of firm position should also be expanded to include short term solvency since the same criteria were used to arrive at conclusions.

Table 5.8 Percentage of Agreement between Experts on Short Term Solvency

	expert system	loan officer#1	loan officer#2	loan officer#3
expert system	100%	73%	50%	64%
loan officer#1	73%	100%	55%	82%
loan officer#2	50%	55%	100%	73%
loan officer#3	64%	82%	73%	100%

5.6.4 Long Term Solvency

When predicting long term farm solvency the results are slightly different. Clearly the expert system turns out to have the most agreement with loan officer number three having the next highest amount of agreement. Loan officer number two and one have the two lowest levels of agreement. As discussed in the previous chapter the debt asset ratio along with the trend in equity were the variables driving the decision of the expert system for this prediction. Because the variables affecting long term solvency are fairly clear (debt asset ratio, trend in equity), the experts appeared to use the same criterium as the expert system when arriving at their decision.

Table 5.9 Percentage of Agreement between Experts on Long Term Solvency

	expert	loan #1	loan #2	loan #3
expert system	100%	73%	86%	82%
loan off#1	73%	100%	68%	73%
loan off#2	86%	68%	100%	77%
loan off#3	82%	73%	77%	100%

5.6.6 Sources of Disagreement

When the experts were questioned as to why they arrived at particular conclusions, some clear differences became apparent regarding the criteria used and the criteria they felt most important in arriving at a particular decision.

5.6.6.1 Case Farms

Some of the reasons for disagreement between the expert system and the other experts stemmed from the peculiar nature of the case farms that were analyzed.

When examining the percent agreement for a decision maker on any case farm, there are a total of 12 possible decisions on which there could be agreement or disagreement. The farms that generated more than 5 difference out of the 12 decisions (40% or more disagreement) were counted for each of the experts (expert system and loan officers). The number of cases for each decision maker showing more than 40% disagreement with the other experts are shown in figure 5.3.

Figure 5.3 Number of Cases For each Decision Maker with 40% or More Disagreement.

expert system	==>	9	cases
officer #1	==>	8	cases
officer #2	==>	10	cases
officer #3	==>	10	cases

The disagreement was focussed around the same eleven case farms for each decision maker. Most of these farms were the borderline farms in the grey areas where the circumstances were unclear. For nine of the eleven cases, the debt asset ratio was less than nine percentage points off from the cut off between good and moderate or bad and moderate. For these cases the experts looked at two criteria most often, net income or the magnitude of owners equity. Interest and rent expenses played a lesser role in their decisions.

One case farm which caused the most disagreement among the experts had a debt asset ratio that did not lie in the grey area. This farm had a large negative net income for the income statement period under analysis (over 100,000, which was later discovered to be related to a large capital loss). Some of the experts attached more weight to this figure than others. Another case farm not in this grey area also had a negative net income which influenced the decisions of some experts more than others. It appears that the experts were looking at not just whether or not net income was positive or negative but by what magnitude.

5.6.6.2 Decision Criteria

As discussed above there were special circumstances for some of the case farms which caused experts to disagree with one another. There were also specific decisions where the experts used different criteria to arrive at their conclusions than the expert system. Section 5.6.2 points out that some experts were using net income to influence their decision regarding credit risk. For the two case farms with a large negative net income, it was this fact that appeared to influence the other experts. The experts also seemed to use the magnitude of owners equity to arrive at an assessment of short term solvency.

During interviews, when constructing the rules of the knowledge base most of the experts agreed that net income in one period should not be used as dominant criteria in assessing firm position. It appears however, that for some cases the experts did not follow this rule.

The magnitude of owners equity is a criterium that did not enter into the decision process of the expert system. When questioned about the reasoning behind their decisions that differed from the expert system, two of the experts tended to mention the magnitude of equity. One expert used magnitude of equity for two decisions and the other expert used it for five decisions. In two situations the decision maker looked at the size of equity and compared it to the number of cows, an interesting concept.

Some of the weaknesses of the knowledge base came to light during this test. In it's present form the decision rules do not look at magnitudes for net income, equity, or withdrawals. This would have required the addition of many more rules. However, the addition of some rules to highlight cases with unusual circumstances may prevent errors in the categorization process. For example a case suffering a large capital loss during one period should be noted by the knowledge base.

Another weakness of the expert system comes from the dominant role played by the debt asset ratio in many of the decisions. It is apparent that the addition of more rules for a later version of the knowledge base to process borderline cases using additional criteria would improve the decisions of the expert system.

5.6.6.3 Additional Information

When asked which additional information they would need to make a quick assessment of a farm operation, one out of the three loan officers said they would like to see production per cow for each farm. Two out of the three loan officers said it would help them to know something about the character of the farmer.

An interesting fact worth noting is the reaction of one of the loan officers after he found out who the identity of the farmer. After interviewing loan officer number three, he was shown several income statements and balance sheets for two of the case farms he analyzed. These two farms, case O and N came from the records in his office so he knew the farmers as soon as he saw the financial statements. For case farm O, he would have down graded his assessment from good to moderate thus making the same decision as the expert system. For case N he would not have changed his original decision which also differed from the expert system.

This illustrates an important concept. The judgement of character would be difficult to capture in an expert system without extraordinary time and effort. Another reason why expert systems will not likely replace experts but will be used to support their decisions.

5.6.7 Case Farm Financial Positions Today

Of the twenty seven farms analyzed, twenty three are still in business today with their balance sheets looking relatively the same as in 1984. One of these twenty three, case farm Z, who was technically insolvent in 1984 and still is in 1986 is not legally bankrupt as of yet. It appears that the creditors are postponing the initiation of foreclosure action.

Three case farms are in the whole dairy herd buy out program, case A,M and P none of these three farms were in serious financial trouble. Case M and P were moderate and case A was in good financial position. The only farm that was liquidated was case farm G. This farm had a debt asset ratio of 65% in 1984 with a decreasing trend thus giving it a moderate rating for financial position and short term solvency but a poor rating for long term solvency by the expert system. All three of the other experts gave it a poor rating for financial position and long term solvency while two of them rated the farm moderate for short term solvency. It is hoped that this kind weakness in the expert system will be overcome with the next version.

CHAPTER VI

SUMMARY AND CONCLUSIONS

6.1 Summary

An expert system was constructed to assess firm financial position of farms, predict financial solvency and to diagnose possible business problems using financial records of the lender. This expert system was constructed in two stages. A prototype was first built that attempted to perform these tasks using the knowledge and experience of this researcher acting as the knowledge engineer and domain expert. This prototype was then taken to various domain experts to obtain suggestions for improvement. After several interviews with experts, an expert system model was constructed that would perform the above tasks.

The data from twenty seven case farms was obtained from Farm Credit Services and Farmers Home Administration to test the expert system prototype. The financial data was prepared for use by the expert system using an electronic spreadsheet. This financial spreadsheet containing all the balance sheet and income statement information for the twenty seven case farms performed the necessary numerical calculations that would have been more cumbersome using the symbolic processing of an expert system.

The expert system was tested against three other experts to compare it's decisions with those who perform the same tasks every day in their work. The same variables calculated by the spreadsheet and read by the expert system were presented to three loan officers. The decisions of the three loan officers were recorded and compared with those of the expert system.

6.2 Conclusions

6.2.1 Management Criteria

One goal of this research was to assemble standards of management criteria that could be used to analyze loan records and provide managers signals of possible problem areas of the business. There were two major problems encountered when attempting to fulfill this goal. The loan records were not of sufficient detail to provide the necessary data for a comprehensive analysis of management criteria. Such information as the enterprise mix, total number of workers, and total acres farmed could not always be determined just using loan records.

The other problem stemmed from the restrictive assumptions under which the management criteria could be applied. The guidelines used for this research required that the dairy farm either grow 100 percent of their feed or buy 100 percent of their feed. Because of the great diversity found out on farms, there were no guidelines developed for farms that were not either of these two categories. To look at management problems on these farms would require detailed enterprise budgets not available with loan records. To circumvent this problem average Telfarm expenses for various expense categories were used in the expert system as guidelines. Using these averages as a basis of comparison a farm's expenses could provide a signal to the manager if significantly high or low. Thus the analysis should be looked at as the first step of a more detailed analysis of firm problems.

The following conclusions apply to this portion of the research:

1. More research is needed to develop management guidelines for dairy farms that grow only a portion of their feed or buy only a portion of the feed that is normally grown on the farm.

2. The decision rules in this expert system including those containing Telfarm averages should be looked at as the first stage of a more detailed analysis. This more

detailed analysis would be performed using records available on the farm.

3. The records of FmHA are not of sufficient detail to perform any financial analysis.

4. Expert systems show promise for providing a means to heuristically tie together management criteria for specific classes of farms to facilitate financial analysis.

6.2.2 Firm Categorization

Another goal of this research was to construct a set of decision rules that would categorize farms according to their present financial condition. The decisions from this portion of the knowledge base were compared with those of loan officers to determine whether or not the expert system performed as consistent another expert. The following conclusions were made regarding this test.

1. The results from the test for agreement between expert system and experts indicate that the knowledge base performed as well as the other experts. The evidence indicates that the expert system tended to draw conclusions that were line with the common opinion of the other decision makers.

2. Interviews with experts during the knowledge engineering phase of this research indicated that the

dominant criteria used by loan officers for assessing firm position was the debt asset ratio.

3. The testing phase of the research project highlighted some weaknesses in the knowledge base. Farm cases with a debt asset ratio close to the cut off point between categories did not receive full scrutiny of other performance criteria or management factors. Also the knowledge base did not adequately address situations where farms had large losses of net income or equity in one period.

4. The conclusions of the expert system regarding credit risk and short term solvency had a lower level of agreement with the other experts as the decisions on overall firm position and long term solvency. The knowledge base should be amended to assess only the firm's position and long term solvency and combine the definition of firm's position with that of credit risk and prospects of short term solvency.

5. The expert system represents a good attempt to classify firms and present conclusions tailored to the specific conditions on the farm by providing individualized output.

6.3 Further Research

Expert systems show promise for assisting in solving problems for the domain of agricultural finance. From the work on this research project there several directions for future exploration that became apparent.

1. The knowledge base in it's present form will perform firm classification but does not make any recommendations as to what the managers options may be. More work is needed to fashion the conclusions of the knowledge base to include management recommendations for the farmer.

2. The option of amending the knowledge base should be explored in order to address firms near the cut off points between categories and farms with large single period losses.

3. Since this knowledge base was constructed as a first stage in a more detailed analysis, further research is needed to design the decision rules for performance of this analysis using on-farm records.

4. This knowledge base could be looked at as a small branch of a much larger decision tree designed to analyze records for other classes of farm firms such as beef, hog or cash crop farms. Research has to be carried out to design the decision rules to perform analysis for these farms.

5. A future application for this knowledge base would be to eliminate data preparation using the financial spreadsheet and make changes in the knowledge base that would allow it to access computerized farm record

keeping systems. Using a spreadsheet to gather and prepare financial information can be labor intensive. The knowledge base could be revised to receive all data from the computer records with no interactively obtained facts. This would automate part of the process of financial analysis.

The expert system model built for this research as with most decision support systems will continue to evolve over time. It will likely change much from the form depicted in this research document. This research project has provided a useful opportunity to shed some light on how to apply expert system technology toward problem solving in the agricultural sector.

APPENDIX A
CASE FARM VARIABLES CALCULATED BY SPREADSHEET

CASE "A"

1984 equity	N	442594
trend in equity	N	-0.0668
1984 D/A ratio	N	0.36118
interest &rent/ gross inc	N	0.31945
purch feed/ cwt milk ship	N	0.30283
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.15691
mach invest per acre	N	181.231
acres farmed per cow	N	8.325
1984 net income	N	-3218
1984 withdraw - outside inc	N	-11000
number of cows	N	40
$ shipped/ full time equiv	N	263835.
1984 repair expense	N	3866
1984 fuel expense	N	4211
1984 fert expense	N	2548
# years of balance sheets	N	5
1984 cost of hired labor	N	9155

CASE "B"

1984 equity	N	378266
trend in equity	N	0.06245
1984 D/A ratio	N	0.48059
interest &rent/ gross inc	N	0.20594
purch feed/ cwt milk ship	N	2.69313
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.19184
mach invest per acre	N	322.9
acres farmed per cow	N	5.60747
1984 net income	N	6725
1984 withdraw - outside inc	N	-20000
number of cows	N	107
$ shipped/ full time equiv	N	507352
1984 repair expense	N	17450
1984 fuel expense	N	9594
1984 fert expense	N	34501
# years of balance sheets	N	4
1984 cost of hired labor	N	9715

CASE "C"

1984 equity	N	211931
trend in equity	N	-0.2196
1984 D/A ratio	N	0.69062
interest &rent/ gross inc	N	0.32151
purch feed/ cwt milk ship	N	2.34745
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.10383
mach invest per acre	N	230.75
acres farmed per cow	N	3.88349
1984 net income	N	-29092
1984 withdraw - outside inc	N	-21388
number of cows	N	103
$ shipped/ full time equiv	N	294691.
1984 repair expense	N	12289
1984 fuel expense	N	9639
1984 fert expense	N	13900
# years of balance sheets	N	4
1984 cost of hired labor	N	9057

CASE "D"

1984 equity	N	174673
trend in equity	N	-0.2492
1984 D/A ratio	N	0.67046
interest &rent/ gross inc	N	0.20562
purch feed/ cwt milk ship	N	3.61432
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.38541
mach invest per acre	N	236.944
acres farmed per cow	N	4.44444
1984 net income	N	-21472
1984 withdraw - outside inc	N	0
number of cows	N	81
$ shipped/ full time equiv	N	442471.
1984 repair expense	N	8330
1984 fuel expense	N	7096
1984 fert expense	N	3878
# years of balance sheets	N	4
1984 cost of hired labor	N	10090

CASE "E"

1984 equity	N	283907
trend in equity	N	-0.0231
1984 D/A ratio	N	0.19838
interest &rent/ gross inc	N	0.31828
purch feed/ cwt milk ship	N	1.02110
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.58623
mach invest per acre	N	138.888
acres farmed per cow	N	7.2
1984 net income	N	-100285
1984 withdraw - outside inc	N	-4000
number of cows	N	50
$ shipped/ full time equiv	N	129924.
1984 repair expense	N	5587
1984 fuel expense	N	3344
1984 fert expense	N	989
# years of balance sheets	N	4
1984 cost of hired labor	N	1340

CASE "F"

1984 equity	N	174243
trend in equity	N	-0.2723
1984 D/A ratio	N	0.71787
interest &rent/ gross inc	N	0.34889
purch feed/ cwt milk ship	N	0.80150
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.11969
mach invest per acre	N	0
acres farmed per cow	N	2.63157
1984 net income	N	12108
1984 withdraw - outside inc	N	-4606
number of cows	N	76
$ shipped/ full time equiv	N	356231.
1984 repair expense	N	3163
1984 fuel expense	N	4805
1984 fert expense	N	1966
# years of balance sheets	N	4
1984 cost of hired labor	N	4267

CASE "G"

1984 equity	N	116217
trend in equity	N	-0.3797
1984 D/A ratio	N	0.65309
interest &rent/ gross inc	N	0.34765
purch feed/ cwt milk ship	N	3.90899
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.26408
mach invest per acre	N	224.583
acres farmed per cow	N	3.75
1984 net income	N	14343
1984 withdraw - outside inc	N	10960
number of cows	N	80
$ shipped/ full time equiv	N	127986.
1984 repair expense	N	2000
1984 fuel expense	N	2700
1984 fert expense	N	2000
# years of balance sheets	N	4
1984 cost of hired labor	N	0

CASE "H"

1984 equity	N	414684
trend in equity	N	-0.5778
1984 D/A ratio	N	0.56889
interest &rent/ gross inc	N	0.25241
purch feed/ cwt milk ship	N	3.50150
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.56424
mach invest per acre	N	123.626
acres farmed per cow	N	8.98765
1984 net income	N	-10141
1984 withdraw - outside inc	N	0
number of cows	N	81
$ shipped/ full time equiv	N	549763.
1984 repair expense	N	30361
1984 fuel expense	N	11558
1984 fert expense	N	11227
# years of balance sheets	N	4
1984 cost of hired labor	N	13452

CASE "I"

1984 equity	N	286104
trend in equity	N	-0.0722
1984 D/A ratio	N	0.40229
interest &rent/ gross inc	N	0.14594
purch feed/ cwt milk ship	N	2.89842
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.32118
mach invest per acre	N	126.991
acres farmed per cow	N	7.2
1984 net income	N	21849
1984 withdraw - outside inc	N	-14843
number of cows	N	50
$ shipped/ full time equiv	N	444914.
1984 repair expense	N	10352
1984 fuel expense	N	4461
1984 fert expense	N	1808
# years of balance sheets	N	4
1984 cost of hired labor	N	10369

CASE "J"

1984 equity	N	588101
trend in equity	N	0.21958
1984 D/A ratio	N	0.45709
interest &rent/ gross inc	N	0.19341
purch feed/ cwt milk ship	N	0.89244
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.99552
mach invest per acre	N	372.460
acres farmed per cow	N	3.01360
1984 net income	N	-18866
1984 withdraw - outside inc	N	-38411
number of cows	N	147
$ shipped/ full time equiv	N	534289.
1984 repair expense	N	21069
1984 fuel expense	N	11527
1984 fert expense	N	28425
# years of balance sheets	N	2
1984 cost of hired labor	N	64381

CASE "K"

1984 equity	N	901772
trend in equity	N	0.13286
1984 D/A ratio	N	0.09926
interest &rent/ gross inc	N	0.11684
purch feed/ cwt milk ship	N	2.17091
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.18647
mach invest per acre	N	251.146
acres farmed per cow	N	2.88961
1984 net income	N	69484
1984 withdraw - outside inc	N	-52355
number of cows	N	154
$ shipped/ full time equiv	N	559873.
1984 repair expense	N	12692
1984 fuel expense	N	8290
1984 fert expense	N	18242
# years of balance sheets	N	3
1984 cost of hired labor	N	41377

CASE "L"

1984 equity	N	254314
trend in equity	N	0.27656
1984 D/A ratio	N	0.48127
interest &rent/ gross inc	N	0.22060
purch feed/ cwt milk ship	N	2.50260
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.18933
mach invest per acre	N	384.090
acres farmed per cow	N	2.75
1984 net income	N	-15140
1984 withdraw - outside inc	N	1360
number of cows	N	80
$ shipped/ full time equiv	N	234861.
1984 repair expense	N	8019
1984 fuel expense	N	8058
1984 fert expense	N	30075
# years of balance sheets	N	3
1984 cost of hired labor	N	6456

CASE "M"

1984 equity	N	500264
trend in equity	N	0.03258
1984 D/A ratio	N	0.51431
interest &rent/ gross inc	N	0.18385
purch feed/ cwt milk ship	N	1.75196
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.17869
mach invest per acre	N	234.871
acres farmed per cow	N	4
1984 net income	N	-31246
1984 withdraw - outside inc	N	-19868
number of cows	N	130
$ shipped/ full time equiv	N	595427.
1984 repair expense	N	18128
1984 fuel expense	N	13451
1984 fert expense	N	25383
# years of balance sheets	N	3
1984 cost of hired labor	N	41695

CASE "N"

1984 equity	N	384931
trend in equity	N	0.25966
1984 D/A ratio	N	0.35882
interest &rent/ gross inc	N	0.35859
purch feed/ cwt milk ship	N	1.12282
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.49793
mach invest per acre	N	0
acres farmed per cow	N	5.02857
1984 net income	N	-19837
1984 withdraw - outside inc	N	-20000
number of cows	N	70
$ shipped/ full time equiv	N	253914.
1984 repair expense	N	4567
1984 fuel expense	N	3127
1984 fert expense	N	10298
# years of balance sheets	N	2
1984 cost of hired labor	N	975

CASE "O"

1984 equity	N	408294
trend in equity	N	-0.0056
1984 D/A ratio	N	0.49276
interest &rent/ gross inc	N	0.14417
purch feed/ cwt milk ship	N	1.86057
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.11887
mach invest per acre	N	439.393
acres farmed per cow	N	3.3
1984 net income	N	22069
1984 withdraw - outside inc	N	-13000
number of cows	N	100
$ shipped/ full time equiv	N	237023.
1984 repair expense	N	4853
1984 fuel expense	N	4890
1984 fert expense	N	18183
# years of balance sheets	N	3
1984 cost of hired labor	N	0

CASE "P"

1984 equity	N	254314
trend in equity	N	0.27688
1984 D/A ratio	N	0.48127
interest &rent/ gross inc	N	0.18454
purch feed/ cwt milk ship	N	2.17251
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.36971
mach invest per acre	N	232.782
acres farmed per cow	N	5.18571
1984 net income	N	20861
1984 withdraw - outside inc	N	-10000
number of cows	N	70
$ shipped/ full time equiv	N	251367.
1984 repair expense	N	11066
1984 fuel expense	N	6223
1984 fert expense	N	23509
# years of balance sheets	N	3
1984 cost of hired labor	N	8276

CASE "Q"

1984 equity	N	513177
trend in equity	N	0.13254
1984 D/A ratio	N	0.25396
interest &rent/ gross inc	N	0.08526
purch feed/ cwt milk ship	N	1.00525
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.39473
mach invest per acre	N	312.5
acres farmed per cow	N	3.96039
1984 net income	N	59208
1984 withdraw - outside inc	N	-16753
number of cows	N	101
$ shipped/ full time equiv	N	1345203
1984 repair expense	N	10529
1984 fuel expense	N	10131
1984 fert expense	N	22314
# years of balance sheets	N	2
1984 cost of hired labor	N	43607

CASE "R"

1984 equity	N	376036
trend in equity	N	0.05745
1984 D/A ratio	N	0.46075
interest &rent/ gross inc	N	0.21713
purch feed/ cwt milk ship	N	1.89115
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.23517
mach invest per acre	N	450
acres farmed per cow	N	3.60360
1984 net income	N	53320
1984 withdraw - outside inc	N	-33899
number of cows	N	111
$ shipped/ full time equiv	N	598025
1984 repair expense	N	10784
1984 fuel expense	N	8449
1984 fert expense	N	11999
# years of balance sheets	N	2
1984 cost of hired labor	N	2563

CASE "S"

1984 equity	N	121532
trend in equity	N	0
1984 D/A ratio	N	0.78745
interest &rent/ gross inc	N	0.17876
purch feed/ cwt milk ship	N	0.45881
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0
mach invest per acre	N	0
acres farmed per cow	N	4.16867
1984 net income	N	20322
1984 withdraw - outside inc	N	-15000
number of cows	N	83
$ shipped/ full time equiv	N	542767.
1984 repair expense	N	0
1984 fuel expense	N	18749
1984 fert expense	N	9010
# years of balance sheets	N	1
1984 cost of hired labor	N	15715

CASE "T"

1984 equity	N	345622
trend in equity	N	-0.0643
1984 D/A ratio	N	0.46495
interest &rent/ gross inc	N	0.19941
purch feed/ cwt milk ship	N	0.90049
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0
mach invest per acre	N	0
acres farmed per cow	N	7.5
1984 net income	N	20766
1984 withdraw - outside inc	N	-2539
number of cows	N	56
$ shipped/ full time equiv	N	262587.
1984 repair expense	N	0
1984 fuel expense	N	5263
1984 fert expense	N	8635
# years of balance sheets	N	2
1984 cost of hired labor	N	28068

CASE "U"

1984 equity	N	266940
trend in equity	N	0
1984 D/A ratio	N	0.43213
interest &rent/ gross inc	N	0.15535
purch feed/ cwt milk ship	N	4.18230
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.05590
mach invest per acre	N	135.609
acres farmed per cow	N	6.59090
1984 net income	N	-911
1984 withdraw - outside inc	N	-15000
number of cows	N	66
$ shipped/ full time equiv	N	311981.
1984 repair expense	N	5000
1984 fuel expense	N	3119
1984 fert expense	N	16379
# years of balance sheets	N	1
1984 cost of hired labor	N	0

CASE "V"

1984 equity	N	109136
trend in equity	N	0
1984 D/A ratio	N	0.75347
interest &rent/ gross inc	N	0.28270
purch feed/ cwt milk ship	N	1.93297
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	1.21644
mach invest per acre	N	206.798
acres farmed per cow	N	8.40476
1984 net income	N	-17526
1984 withdraw - outside inc	N	-11878
number of cows	N	42
$ shipped/ full time equiv	N	161125
1984 repair expense	N	4464
1984 fuel expense	N	7965
1984 fert expense	N	22544
# years of balance sheets	N	1
1984 cost of hired labor	N	959

CASE "W"

1984 equity	N	74670
trend in equity	N	0
1984 D/A ratio	N	0.82417
interest &rent/ gross inc	N	0.18739
purch feed/ cwt milk ship	N	4.15732
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.20786
mach invest per acre	N	300
acres farmed per cow	N	15.52
1984 net income	N	33800
1984 withdraw - outside inc	N	-680
number of cows	N	25
$ shipped/ full time equiv	N	384863.
1984 repair expense	N	12600
1984 fuel expense	N	4104
1984 fert expense	N	18500
# years of balance sheets	N	1
1984 cost of hired labor	N	1200

CASE "X"

1984 equity	N	42578
trend in equity	N	0
1984 D/A ratio	N	0.71176
interest &rent/ gross inc	N	0.33071
purch feed/ cwt milk ship	N	4.13856
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.60668
mach invest per acre	N	46.6292
acres farmed per cow	N	4.94444
1984 net income	N	-7308
1984 withdraw - outside inc	N	8000
number of cows	N	18
$ shipped/ full time equiv	N	118265.
1984 repair expense	N	1520
1984 fuel expense	N	974
1984 fert expense	N	691
# years of balance sheets	N	1
1984 cost of hired labor	N	71

CASE "Y"

1984 equity	N	149760
trend in equity	N	0.08816
1984 D/A ratio	N	0.63704
interest &rent/ gross inc	N	0.21958
purch feed/ cwt milk ship	N	1.18739
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.51634
mach invest per acre	N	332.64
acres farmed per cow	N	5.20833
1984 net income	N	21245
1984 withdraw - outside inc	N	-17169
number of cows	N	48
$ shipped/ full time equiv	N	370390.
1984 repair expense	N	9206
1984 fuel expense	N	6913
1984 fert expense	N	8816
# years of balance sheets	N	2
1984 cost of hired labor	N	744

CASE "Z"

1984 equity	N	-10535
trend in equity	N	-1.0315
1984 D/A ratio	N	1.01167
interest &rent/ gross inc	N	0.38466
purch feed/ cwt milk ship	N	1.25214
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.10879
mach invest per acre	N	252.71
acres farmed per cow	N	3.70370
1984 net income	N	-276818
1984 withdraw - outside inc	N	-20000
number of cows	N	162
$ shipped/ full time equiv	N	600223.
1984 repair expense	N	28357
1984 fuel expense	N	8780
1984 fert expense	N	8970
# years of balance sheets	N	4
1984 cost of hired labor	N	17106

CASE "ZA"

1984 equity	N	325547
trend in equity	N	-0.1316
1984 D/A ratio	N	0.64153
interest &rent/ gross inc	N	0.52872
purch feed/ cwt milk ship	N	1.29666
vet expense/ cwt milk ship	N	0
breed expense/ cwt milk ship	N	0
lvstk expense/ cwt milk ship	N	0.03306
mach invest per acre	N	382.5
acres farmed per cow	N	4.08163
1984 net income	N	-47931
1984 withdraw - outside inc	N	-25983
number of cows	N	98
$ shipped/ full time equiv	N	312494.
1984 repair expense	N	10494
1984 fuel expense	N	9645
1984 fert expense	N	19750
# years of balance sheets	N	4
1984 cost of hired labor	N	13215

APPENDIX B

EXPERT SYSTEM CONCLUSION EXAMPLE

The following is an example of the output from the expert system after completion of the analysis. Each paragraph represents the conclusions from a different portion of the knowledge base.

CASE FARM B

1. Number of balance sheet years and cautionary note

The firm has provided three or more years of balance sheet information. With a larger number of years analyzed there can be more faith in the predictions of the knowledge base regarding firm solvency. Although three or four years of data is enough to activate the rules that will predict solvency, the reader should be careful when interpreting the analysis. For example a recent restructuring of the farm business will likely lead to incorrect results.

2. Livestock expenses (breeding and vet expenses)

The data indicates that this farm is spending 0.20 dollars per hundredweight of milk shipped on livestock expenses. This is below the standard of 58 cents to 45 cents per hundredweight. Livestock expenses include vet, breeding and semen costs. Low livestock expenses due to low veterinary costs should be evaluated to be sure there is an adequate herd health program. Low semen costs may indicate the need for an evaluation of the breeding program.

3. Purchased feed expenditures

The farm is spending more on purchased feed than the standard of $2.4 per hundredweight of milk shipped. The high measure of 2.8 indicates that the feed ration may need analysis or the feed crop enterprises may need improvement.

4. Machinery investment

Machinery investment of $322.9 per feed crop acres appears high compared to the standard. Research has shown that a farm that is growing only feed crops for dairy cows should not have to invest more than 250 dollars per acre in machinery.

5. Acres Farmed per Cow

Compared to the standard this farm appears to be using more land than the average of 5 acres per cow for feed crops. This farms acres farmed per cow of 5.6 indicates a possible overinvestment in land or low productivity of feed crop enterprises.

6. Labor efficiency

For free stall housing systems an operation should be shipping over 600,000 lbs per FTE (full time equivalent) per year. FTE includes hired, all family and also the proprietor's labor. One FTE equals 3000 hours. This farm is shipping 495460.00 per FTE which may be an indication that labor needs to be more productive.

7. Repair Expenditures

Repair expenses are 65.00 per cent of the average. A low repair expense is usually not an indication of problems on a farm but rather the lack of. However a number of less than 50 % may indicate unrecorded expenses or a need for a better maintenance program. Low repair expenses may mean that there is new equipment on the farm.

8. Fuel Expenditures

Fuel expenses are 71.07 per cent of the average. A number of less than 75 % may indicate the need for a better tillage program. There may be a need for more field preparation. Low fuel expenses may also be due to idled crop land.

9. Fertilizer Expenditures

Fertilizer and chemical expenses are above the average by 33.21 per cent. A number of more than 25% may indicate that field operations need investigation. High fertilizer expenses may indicate prepaid expenses of fertilizer that will be used next year or it may also be due to the presence of cash crop enterprises. There may also be alternative, less expensive forms of fertilizer available. The manager should examine the returns to fertilizer costs to be sure appropriate revenues are being obtained from the high fertilizer costs.

10. Labor expenditures

Labor expenses are 24.53 per cent of the average. A number of less than 75 % may indicate a possible need for more hired labor Ron the farm.

11. Firm Classification and Individualized Output

Previous balance sheet information indicates that this firm has been maintaining equity. The moderate debt asset ratio of 0.48 indicates less vulnerability to price variations and adverse weather conditions. The median interest and rent expenses of 0.21 could erode profits in poor years. The farm does not have adequate net income to support withdrawals. The farm has provided 4 years of data with an equity trend of 0.062. The following conclusions can be reached about this farm.

- Farm has an overall moderate financial position.
- Farm is in a moderate risk category
- Prospects for near term solvency (2 to 3 years) and long term are moderate.

APPENDIX C

EXPERT SYSTEM KNOWLEDGE BASE EXAMPLE RULES AND KEY WORDS

The following is a discussion of the syntax and construction of some of the expert system decision rules in the prototype developed in this research. The discussion will be specific to Insight Two Plus since this was the shell chosen for knowledge representation in this project.

VARIABLE AND GOAL DECLARATION

The key word NUMERIC is used to declare variables that will be processed by the knowledge base as either real or integer numbers. This is done at the beginning of the knowledge base.

```
NUMERIC  EQUITY
AND      DETAST
AND      INRNGI
AND      PURFD
AND      NETINC
AND      WITH
AND      HIGHG
AND      REPR
AND      HIRED
.
.
.
```

The reserved word CONFIDENCE OFF will turn off certainty factors so that the expert system shell will not require the user to specify a level of certainty with their responses.

```
CONFIDENCE OFF
```

This portion of the program uses the key word SUPPRESS to tell the expert system shell which conclusions that should not be displayed to the user.

```
SUPPRESS Farm analysis is possible
AND      The farm is profitable
AND      The farm is holding it's own
AND      The farm appears to be sound
AND      Feed expense is high
.
.
.
```

This next section "defining the goals of the knowledge base" is one of the most important. It determines the general structure of the knowledge base and the order in which the goals will be processed. For example below the knowledge base will prove "Continue analysis first before proving the goal "Data quality determined." Each goal is recursively proven until the final goal is achieved which in this case is "solvency trend determined." In this manner the knowledge base is a deterministic decision tree.

Define the goals of the knowledge base.

```
1.           Continue analysis
1.1           Data quality determined
1.1.1           Management factor analysis complete
1.1.1.1           Livestock expenses analyzed
1.1.1.1.1           TelFarm factors investigated
1.1.1.1.1.1           Solvency trend determined
```

PRELIMINARY RULES

The first rule of the program that reads the variables calculated by the spreadsheet and stored in an ASCII file called "DAIRY.PRN" is shown below. Note the READ reserved word used to tell the shell to read file DAIRY.PRN from a disk.

```
RULE     To read in the data required for analysis
READ     DAIRY.PRN
AND      DETAST
AND      INRNGI
AND      PURFD
AND      NETINC
AND      WITH
.
.
.
THEN     Continue analysis
```

Note "continue analysis" which is the first goal of the knowledge base. Once this rule is fired the goal is proven and the expert system moves on to the next goal.

USE OF FINANCIAL VARIABLES

This section of the appendix illustrates the use of each financial variable read into the expert system. These variables are numbered according to the order in which they were discussed in chapter four. This is done to assist the reader in finding specific uses in the expert system for these variables.

The first set of rules represent the section of the knowledge base that determines how many years of balance sheet information has been provided. Note that the conclusion "Data quality determined" is the second goal of the knowledge base. The goals do not however have to be presented in any particular order.

2. Number of Balance Sheet Years Provided

```
RULE      Determination of good data quality
IF        Continue analysis
AND       YEARS > 2
THEN      data ok
AND       PRINT Quality of the data is OK
AND       Data quality determined
!
RULE      Determination of poor data quality
IF        Continue analysis
AND       YEARS = 2
THEN      Data so so
AND       PRINT Quality of the data is not very reliable
AND       Data quality determined
!
RULE      Determination of very poor data quality
IF        Continue analysis
AND       YEARS = 1
THEN      Data poor
AND       PRINT Quality of the data is not reliable
AND       Data quality determined
```

FIRM CLASSIFICATION

The rules are for the most part self explanatory. The first rule looks to see if no balance sheet information has been supplied which will terminate the goal "solvency trend determined." The section below represents the largest portion of the knowledge base. This is the portion of the rules that assess firm position and predict firm solvency. These rules also provide the information needed to write individualized output to each possible farm scenario.

1. Owners Equity

```
RULE      To terminate the prediction of solvency
IF        Continue analysis
AND       YEARS = 0
THEN      There is no balance sheet information
AND       PRINT  No data supplied
AND       Data quality determined
AND       Solvency trend determined
```

```
RULE     Determination of current solvency
IF       Continue analysis
AND      Equity < 0
THEN     The farm has a negative equity
AND      PRINT The farm is technically insolvent
AND      Solvency trend determined
```

The following rules provide individual assessments of risk for firms providing only one year of data.

```
RULE     To assess future prospects for the firm
IF       Continue analysis
AND      Equity >= 0
AND      YEARS = 1
AND      DETAST >= .70
AND      INRNGI >= .15
AND      NETINC + WITH <= 0
THEN     high credit risk
AND      PRINT  This firm is a high credit risk
AND      Solvency trend determined
!
RULE     To assess future prospects for the firm profits
IF       Continue analysis
AND      Equity >= 0
AND      YEARS = 1
AND      DETAST >= .70
AND      INRNGI >= .15
AND      WITH + NETINC > 0
THEN     credit risk but profitable
AND      PRINT  Firm is a credit risk but profitable
AND      Solvency trend determined
```

3. Trend in owners equity & Trend in Asset Values

The next section of rules combine the trend in owners equity with the trend in inflation or deflation to see for example if a positive trend in equity is due to inflation or retained   earnings from previous years.

```
RULE      To see if equity trends down under inflation
IF        Continue analysis
AND       Equity >= 0
AND       TREN < 0
AND       Trend in asset values IS increasing
THEN      Operation of farm is eroding net worth
RULE      To see if equity is trending up under deflation
IF        Continue analysis
AND       Equity >= 0
AND       TREN  > 0
AND       Trend in asset values IS decreasing
THEN      The farm is profitable
!
RULE      To see if equity fluctuates under deflation
IF        Continue analysis
AND       Equity >= 0
AND       TREN = 0
AND       Trend in asset values IS decreasing
THEN      The farm is holding it's own
!
RULE      To see if equity fluctuates under inflation
IF        Continue analysis
AND       Equity >= 0
AND       TREN = 0
AND       Trend in asset values IS increasing
THEN      Fluctuating equity due to unprofitability
!
RULE      is inflation rate is higher than equity
increase
IF        Continue analysis
AND       Equity >= 0
AND       TREN > 0
AND       Trend in asset values IS increasing
AND       Asset values ARE increasing faster than equity
THEN      Farm profitability needs investigation
!
RULE      To see if equity trends up under inflation
IF        Continue analysis
AND       Equity >= 0
AND       TREN > 0
AND       Trend in asset values IS increasing
AND       Assets ARE not increasing faster than equity
THEN      The farm appears to be sound
!
RULE      is equity decrease due to deflation
IF        Continue analysis
AND       Equity >= 0
AND       TREN < 0
AND       Trend in asset values IS decreasing
AND       Assets ARE decreasing faster than equity
THEN      The farm appears to be profitable
```

```
RULE     To see if equity decrease is due to deflation
IF       Continue analysis
AND      Equity >= 0
AND      TREN < 0
AND      Trend in asset values IS decreasing
AND      Assets ARE not decreasing faster than equity
THEN     The farm may not be profitable
```

4. Debt Asset Ratio

The next three rules look at the debt asset ratio to see if it is high, moderate or poor. The conclusion " The farm appears to have too much debt " puts the farm into the high category.

```
RULE     To see if the farm has a large debt asset ratio
IF       DETAST >= .70
THEN     The farm appears to have too much debt
!
RULE     To see if the farm has a median debt asset
ratio
IF       DETAST > .40
AND      DETAST < .70
THEN     Effect of debt on farm solvency depends on farm
profits
!
RULE     To see if the farm has a small debt asset ratio
IF       DETAST <= .40
THEN     The farms debt structure appears to be OK
```

The next 150 rules combine several criteria for purposes of providing individualized output to the user. 5. Interest and Rent Expenses as % of Gross Income (INRNGI) and 6. Net Income & Withdrawals are combined with the conclusions of the previous rules to perform this function. Only six rules are displayed below.

```
RULE     Does large portion of income go to interest
IF       The farms debt structure appears to be OK
AND      The farm appears to be sound
OR       The farm is holding it's own
OR       The farm is profitable
AND      NETINC > 0
AND      WITH > 0
AND      INRNGI >= .25
THEN     expenses are too high
AND      PRINT too high
AND      Solvency trend determined
```

```
RULE     Examine high interest expense good position
IF       The farms debt structure appears to be OK
AND      The farm appears to be sound
OR       The farm is holding it's own
OR       The farm is profitable
AND      INRNGI >= .25
AND      NETINC + WITH < 0
THEN     Problems with profitability
AND      PRINT need profits
AND      Solvency trend determined
!
RULE     To analyze cash flow for the too high farm
IF       The farms debt structure appears to be OK
AND      The farm appears to be sound
OR       The farm is holding it's own
OR       The farm is profitable
AND      INRNGI >= .25
AND      NETINC < 0
AND      WITH > 0
AND      WITH + NETINC > 0
THEN     Cash flow due to with
AND      PRINT  outside income
AND      Solvency trend determined
!
RULE     Does small part of farm income go to interest
IF       The farms debt structure appears to be OK
AND      The farm appears to be sound
OR       The farm is holding it's own
OR       The farm is profitable
AND      NETINC > 0
AND      WITH   < 0
AND      NETINC + WITH > 0
AND      INRNGI >= .25
THEN     expenses and income OK
AND      PRINT interest high debt and income good
AND      Solvency trend determined
!
RULE     Does small part of farm income go to interest
IF       The farms debt structure appears to be OK
AND      The farm appears to be sound
OR       The farm is holding it's own
OR       The farm is profitable
AND      NETINC > 0
AND      WITH   > 0
AND      INRNGI < .25
AND      INRNGI >= .15
THEN     expenses OK
AND      PRINT interest and debt OK
AND      Solvency trend determined
!
```

MANAGEMENT FACTORS

The following section of the knowledge base analyzes management factors and compares those of one farm with standards developed by farm management specialists. The first rule looks to see if the farm manager intends to grow 100% of the feed or else it skips the analysis of feed acres per cow and machinery per acre, three of the variables examined in this section.

```
...............

RULE     To see if farms crop program can be analyzed
IF       The farm grows 100% of its own feed
THEN     Feed enterprises can be analyzed
ELSE     Skip feeding analysis
!
RULE     To see if the farm is spending too much on feed
IF       Feed enterprises can be analyzed
AND      PURFD > 2.6
THEN     Feed expense is high
AND      PRINT  high feed
!
RULE     To see if the farm's feed expense is OK
IF       Feed enterprises can be analyzed
AND      PURFD <= 2.6
AND      PURFD >= 2.4
THEN     Feed expense looks OK
AND      PRINT   Feed expense OK
!
RULE     Is the farm is not spending enough on feed
IF       Feed enterprises can be analyzed
AND      PURFD < 2.4
THEN     Feed expense looks low
AND      PRINT  Feed expense low
!
RULE     To see if the feed expense cannot be analyzed
IF       Feed enterprises can be analyzed
AND      PURFD = 0
THEN     Feed expense cannot be analyzed
AND      PRINT  No data supplied on feed expenditures
!
RULE     To see if the farm machinery investment is high
IF       Feed expense looks OK
OR       Feed expense is high
OR       Feed expense looks low
OR       Feed expense cannot be analyzed
AND      MACH > 250.0
THEN     Machinery investment looks high
AND      PRINT   Machinery investment high
.........
```

TELFARM FACTORS

The following is the final section of the knowledge base. Analysis of selected expenditures are compared to Telfarm averages for various herd sizes to give the manager an idea of how their operation compares to other similar farms. The purpose is to raise a red flag for possible problems.

```
...............

RULE      To analyze repairs expense 50 low
IF        COWS <= 50
AND       REPR < 7500
AND       LOWR := ((REPR)/7500)100
THEN      Repair expenses are below TelFarm average
AND       PRINT Low repair
!
RULE      To analyze repairs expense 75 low
IF        COWS > 50
AND       COWS <= 75
AND       REPR <= 12500
AND       LOWR := ((REPR)/12500)100
THEN      Repair expenses are below TelFarm average
AND       PRINT Low repair
!
RULE      To analyze repairs expense 100 low
IF        COWS > 75
AND       COWS < 100
AND       REPR <= 14000
AND       LOWR := ((REPR)/14000)100
THEN      Repair expenses are below TelFarm average
AND       PRINT Low repair
!
RULE      To analyze repairs expense over 100 low
IF        COWS >= 100
AND       REPR <= 26600
AND       LOWR := ((REPR)/26600)100
THEN      Repair expenses are below TelFarm average
AND       PRINT Low repair
!
RULE      To analyze repairs expense 50 high
IF        COWS <= 50
AND       REPR > 7500
AND       HIGHR := ((REPR - 7500)/7500)100
THEN      Repair expenses are higher than TelFarm avg
AND       PRINT High repair
............
```

PRINTER OUTPUT AND SCREEN DESIGN

This section gives the knowledge engineer the flexibility to sculpture screens and outputs according to the task at hand. Below for the next several pages is a listing of the various methods used to design screens for interactive questions obtained from the user along with all of the conclusions that are sent to the printer. Each clause following the key word DISPLAY represents individualized output to be sent to the printer with a PRINT key word. If the clause has not been identified with a keyword PRINT then the string following the clause will be sent to the screen.

The EXPAND key word is used for help messages during a consultation. The TEXT key word is used to identify strings to be sent to the screen. This is used chiefly in designing the screens that the user will see during a consultation.

DISPLAY   Machinery investment high

Machinery investment of $[MACH (5,1)] per feed crop acres appears high compared to the standard. Research has shown that a farm that is growing only feed crops for dairy cows should not have to invest more than 250 dollars per acre in machinery.

!

DISPLAY   high feed

The farm is spending more on purchased feed than the standard of $2.4 per hundredweight of milk shipped. The high measure of [PURFD (3,1)] indicates that the feed ration may need analysis or the feed crop enterprises may need improvement.

DISPLAY   High fertilizer

Fertilizer and chemical expenses are above the average by [highf (5,2)] per cent. A number of more than 25% may indicate that field operations need investigation. High fertilizer expenses may indicate prepaid expenses of fertilizer that will be used next year or it may also be due to the presence of cash crop enterprises. There may also be alternative, less expensive forms of fertilizer available. The manager should examine the returns to

fertilizer costs to be sure appropriate revenues are being obtained from the high fertilizer costs.
!
DISPLAY Low fertilizer

Fertilizer and chemical expenses are [lowf (5,2)] percent of the average. A number of less than 75 % may indicate problems with the cropping program. Are the feed crop enterprises producing up to their potential? The manager may want to examine the potential returns to additional fertilizer expenditures. A low fertilizer expense may be due to prepaid expenses made the year before.
!
DISPLAY increasing equity lower interest outside income

This farm has signs of having an unsustainable financial position. Despite increases in equity, high debt asset ratio of [DETAST (4,2)] combined with interest and rent expenses as a percent of gross income [INRNGI (4,2)] indicate high vulnerability to low prices and adverse weather conditions. The negative net income of [NETINC (8,2)] is however supported by outside income. If the farm can become profitable there is still an opportunity for improving the firms financial condition.
The farm has provided [YEARS(3,1)] of data with an equity trend of [TREND (5,2)].

- This firm has exhausted credit reserves. Overall position of the farm is poor.

- Farm is a high credit risk

- Prospects for firm survival are moderate in the short and long run

!

This continues for sixty more pages, covering all possible combinations of the financial variables. These combinations are represented using these individualized responses. Also included in this section are all the help messages (prefaced with the key word EXPAND), as well as all the screens for interactive user input.

Each knowledge base includes an END statement at the end.
END

APPENDIX D

EXPERT DECISIONS FOR EACH CASE FARM

Table D.1 Expert System Assessment of Firm Viability

case farm	short term solvency	long term solvency	credit risk	overall position
A	good	good	good	moderate
B	moderate	moderate	moderate	moderate
C	moderate	moderate	moderate	poor
D	moderate	moderate	moderate	poor
E	good	good	good	moderate
F	poor	poor	poor	poor
G	moderate	moderate	moderate	poor
H	moderate	moderate	moderate	poor
I	good	good	good	good
J	moderate	moderate	moderate	moderate
K	good	good	good	good
L	moderate	moderate	moderate	moderate
M	moderate	moderate	moderate	moderate
N	good	good	good	good
O	moderate	moderate	moderate	moderate
P	moderate	moderate	moderate	moderate
Q	good	good	good	good
R	moderate	moderate	moderate	moderate
S			poor	
T	moderate	moderate	moderate	moderate

Table D.1 Expert System Assessment of Firm Viability Continued

case farm	short term solvency	long term solvency	credit risk	overall position
U			moderate	
V			poor	
W			poor	
X			poor	
Y	moderate	moderate	moderate	moderate
Z	poor	poor	poor	poor
ZA	moderate	moderate	moderate	poor

(Blanks indicate firms with only one year of data)

Table D.2 Loan Officer Number One Assessment of Firm Viability

case farm	short term solvency	long term solvency	credit risk	overall position
A	good	good	good	good
B	good	good	good	good
C	moderate	moderate	moderate	poor
D	moderate	moderate	moderate	poor
E	moderate	moderate	moderate	moderate
F	poor	poor	moderate	poor
G	poor	poor	moderate	poor
H	moderate	moderate	moderate	moderate
I	good	good	good	good
J	moderate	moderate	moderate	moderate
K	good	good	good	good
L	moderate	moderate	moderate	poor
M	moderate	moderate	moderate	moderate
N	good	good	good	good
O	good	good	good	moderate
P	moderate	moderate	moderate	moderate
Q	good	good	good	good
R	good	good	good	good
S			poor	
T	moderate	moderate	moderate	moderate
U			moderate	
V			poor	

Table D.2 Loan Officer Number One Assessment of Firm Viability Continued

case farm	short term solvency	long term solvency	credit risk	overall position
W			poor	
X			poor	
Y	poor	poor	poor	poor
Z	poor	poor	poor	poor
ZA	moderate	poor	moderate	poor

(Blanks indicate firms with only one year of data)

Table D.3 Loan Officer Number Two Assessment of Firm Viability

case farm	short term solvency	long term solvency	credit risk	overall position
A	good	good	good	moderate
B	moderate	moderate	good	moderate
C	poor	moderate	moderate	poor
D	moderate	moderate	moderate	poor
E	moderate	good	good	good
F	poor	poor	moderate	poor
G	poor	poor	poor	poor
H	moderate	poor	moderate	poor
I	good	good	good	good
J	good	good	good	moderate
K	good	good	good	good
L	moderate	moderate	moderate	moderate
M	moderate	moderate	good	moderate
N	good	good	moderate	moderate
O	good	good	good	moderate
P	good	good	good	moderate
Q	good	good	good	good
R	good	good	moderate	moderate
S			poor	
T	good	good	good	moderate
U			moderate	
V			poor	
W			poor	

Table D.3 Loan Officer Number Two Assessment of Firm Viability Continued

case farm	short term solvency	long term solvency	credit risk	overall position
X			poor	
Y	moderate	moderate	moderate	poor
Z	poor	poor	poor	poor
ZA	moderate	moderate	poor	poor

(Blanks indicate firms with only one year of data)

Table D.4 Loan Officer Number Three Assessment of Firm Viability

case farm	short term solvency	long term solvency	credit risk	overall position
A	moderate	moderate	good	moderate
B	good	good	good	good
C	poor	poor	moderate	poor
D	moderate	moderate	moderate	poor
E	good	moderate	moderate	poor
F	poor	moderate	moderate	poor
G	poor	moderate	moderate	poor
H	moderate	moderate	moderate	poor
I	moderate	good	good	good
J	good	moderate	moderate	moderate
K	good	good	good	good
L	moderate	moderate	moderate	moderate
M	moderate	moderate	moderate	moderate
N	good	moderate	good	moderate
O	moderate	good	good	moderate
P	moderate	good	good	moderate
Q	good	good	good	good
R	moderate	good	good	good
S			poor	
T	moderate	good	good	moderate
U			moderate	
V			poor	
W			moderate	

Table D.4 Loan Officer Number Three Assessment of Firm Viability Continued

case farm	short term solvency	long term solvency	credit risk	overall position
X			poor	
Y	moderate	moderate	moderate	moderate
Z	poor	poor	poor	poor
ZA	poor	poor	poor	poor

(Blanks indicate firms with only one year of data)

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