Maintaining the Cutting Edge

Proceedings of the American Agricultural Economics Association Extension Workshop

July 31, 1987 - August 1, 1987

East Lansing, Michigan

Editors: Cara L. Mitchell
Kim B. Anderson

Produced at Oklahoma State University

Additional funding provided by Agriculture-Agribusiness Program, Oklahoma Cooperative Extension Service,

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

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This research project represents an attempt to explore opportunities for the farm sector to apply expert system technology to discover answers to farm financial problems. The financial information of twenty nine farms from Farm Credit Services and Farmers Home Administration were used to test an expert system prototype. The results of the test indicated that the expert system achieved the same level of agreement found between loan officers. The results of the research uncovered gaps in knowledge and shed light on expert decision making for the financial analysis of farm businesses.

INTRODUCTION

The farm sector is experiencing a period of financial stress. Many farm businesses have been liquidated since the early part of the decade and most experts agree that restructuring in the agricultural sector will continue for the next few years. (Cochrane, 1987)

Due to the recent decline in farm asset values and the low prices of many agricultural commodities the management of a farm operation is becoming increasingly complex. It requires skills and knowledge in such diverse areas as marketing, epidemiology, production economics, plant physiology, soil physics, human resource management and finance.

Managers process a wealth of information before making management decisions. It has been shown that the human decision maker is prone to error, particularly when a decision is made under time constraints (Hogarth, 1987). Human decision makers employ cognitive simplification strategies when making decisions. However, when expert decision makers are given adequate time and encouraged to solve the problem logically, they will often arrive at the best answer for the information available. Experts are encouraged through the decision making process in a similar logical manner during the building of an expert system. This process of obtaining expert advice for solving a given problem is referred to as knowledge engineering (Harmon & King, 1985).

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Michigan State University Agricultural Experiment Station Bulletin Number 12394.

Farm managers prepare year end financial statements for tax purposes and for their creditors. This is generally the only time they examine their finances. They have little information on other farm firms and therefore have no means of comparison for analyzing their financial statements. They also have few benchmarks or standards available to them for analyzing financial information.

Computerized expert systems show potential for assisting farm management decision makers to analyze financial statements. They incorporate rules of thumb and are adapted to represent the flow characteristics of a given problem. Information can be extracted from the experts by a knowledge engineering process that encourages the experts to think the problem through in order that a conditional best solution be obtained every time.

Hayes-Roth, et. al. 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 indicates that many tasks lack a mathematically tractable core. As a result more and more attention has been focussed in the expert system arena to areas where analytical methods are not well documented but where people are still able to achieve results.

Many farms are experiencing financial difficulties in today's rapidly changing agricultural sector. Both farmers and lenders could benefit from an expert system that would analyze financial statements. The following are some specific tasks an expert system could be used for:

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

Many farm accounting systems provide summaries to their users to assist in analyzing the farm business. Accountants at times also provide consulting services related to the analysis of the business. An expert system could take business analysis a step further by using both the summaries available from computerized farm accounting systems and the financial standards from the farm business consultants. These can both be applied directly toward a given business.

Some loan officer decisions on the granting of credit have been assisted with the use of credit scoring models (Pederson & Duncan, 1983). The credit scoring method uses a discriminate analysis algorithm. This algorithm identifies a linear discriminate function to maximize the ratio of the sum of squares between two groups (Dunn & Frey, 1976). These models rely on statistical relationships and less on financial principals. An analyst does not have the ability to trace the logic of the model and learn more about problem with this method as they would with an expert system.

The potential applications and uses of expert systems in this context are plentiful. An expert system could be used to interface with a farm accounting system to automate the process of financial analysis. Lending institutions would be assisted by having farm cases requiring further attention screened and selected from the portfolio.

Expert systems have already been used by some banks to support decisions on the granting of credit. This facilitates a consistent granting of credit without taking the human decision maker out of the process. Farm managers can be assisted by an expert system of this type in a number of ways. Year end income statements could be screened to highlight potential sources of problems in the business by using benchmarks of good, moderate, or poor performance.

PROJECT OBJECTIVES AND DEVELOPMENT OF FIRST MODEL

The goal of this project was to test the hypothesis that an expert system could make decisions that were consistent with those of human experts. This was accomplished by developing an expert system to analyze dairy farm financial records of the lender. The model is then use to both the lender and the farm manager.

By focussing on dairy farms and using only income statements and balance sheets, a working model was developed within a three to five month period of time.

The following are the goals of the expert system model.

1) To assess the overall financial position of the farm as good moderate or poor.
2) To predict the likelihood of farm business solvency as good, moderate or poor.
3) To compare selected information to management standards in an effort to determine possible sources of business problems.

DATA LIMITATIONS

The names and addresses of the case farms analyzed for this project were unknown to assure anonymity. This prevented the analysis from going beyond the use of income statements (accrual based) and balance sheets (market based).

The use of balance sheets and income statements put limitations on the amount of detail provided by the analysis. Potential problem areas of the business would only be brought to the attention of the analyst. Assessing the causes of these problems requires cost accounting information or partial enterprise budgets, information that is not usually found in the financial records available to the lender.

The use of balance sheets and income statements presents some other problems because of the wide use of cash accounting. Some expense categories may appear higher or lower than a given standard for a given year solely because part of the expense incurred is associated with income earned in a different year. Interpretation of the results of the expert system is performed with this limitation in mind.

FIRST MODEL

The construction, validation and testing of the expert system discussed in this paper was accomplished in several steps. The first step in building the model was to bring together some notion of what financial variables are important along with the thresholds of good, bad, or moderate for these variables. This was accomplished using texts, extension and research publications and interviews with loan officers and farm management specialists.

The problem was then outlined and developed into a prototype expert system using the knowledge and expertise of Harsh and Phillips acting as both the knowledge engineers and domain experts. The prototype that resulted from this was taken to several loan officers and farm management specialists to obtain their suggestions for improvement. These suggestions were incorporated, resulting in a working expert system model.

The first knowledge engineering interviews with experts were difficult and challenging because experts were either not able to articulate their decision making process or did not feel confident in their expertise. The experts were able to select important variables and the relative thresholds for these variables but had difficulty assessing various combinations for the variables at different thresholds. Better results were obtained when the experts were allowed to react to a prototype.

MODEL STRUCTURE

The knowledge base of the expert system at this stage was partitioned into four categories according to goals. These categories were:

1. To assess the overall financial position of the firm and predict solvency.
2. To compare selected expenses with averages for a given size of dairy farm.
3. To analyze feed and cropping practices using expert rules of thumb.
4. To analyzes selected livestock expenditures.

Twenty nine cases were analyzed with the expert system model. Twenty two of these farms came from Farm Credit Services. The other seven farms were obtained from Farmers Home Administration. Seventeen farms had three or more years of financial data, seven farms provided only two years of data and five farms had just one year of data. The financial analysis was carried out with a Lotus 123 spreadsheet and Insight Two plus, an expert system shell. The spreadsheet was used to calculate selected financial variables for each case farm. The variables were written to an ASCII file which was then read by the expert system.

The variables used by the expert system were selected through interviews with experts, text books, readings from the credit scoring literature (Phillips, 1987) The following is a list of these variables:

1) Number of years of balance sheets
2) 1984 equity
3) Trend in equity over the period
4) 1984 Debt/Asset ratio
5) Interest & rent as a percent of gross income
6) Purchased feed per hundredweight of milk shipped
7) Veterinary expense per hundredweight of milk shipped
8) Breeding expense per hundredweight of milk shipped
9) Livestock expense per hundredweight of milk shipped
10) Machinery investment (market basis) per acre
11) Acres farmed per cow
12) 1984 net income
13) 1984 outside income less family withdrawals
14) Number of cows
15) Pounds of milk shipped per worker (full time equivalent)
16) 1984 repair expense
17) 1984 fuel expense
18) 1984 fertilizer expense
19) 1984 cost of hired labor

After the expert system reads these financial variables they are analyzed by a series of decision rules. The structure of the rules in the knowledge base, work like that of a deterministic search tree. The knowledge base is partitioned into four main goals. Within these goals the rules are nested so that the conclusion of one rule is an antecedent to another rule. The inference engine uses a pattern recognition process to

FIGURE 1. PARTIAL SEARCH TREE REPRESENTATION FOR FIRM CLASSIFICATION AND SOLVENCY PREDICTION

Equity < 0 = terminate solvency prediction
Equity > 0

1 year of information
3 or more years of information
2 years of information

equity trend up
equity trend fluctuating
equity trend down

deflation inflation deflation inflation deflation inflation

equity down faster than asset values
assets down faster than equity

Debt/Asset between .65 and .75

Farm is screened for management criteria

Interest & rent as a percent of Gross Income >.25

negative net income
negative outside income less withdrawals

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.

recursively work through the rules until each goal is proven (Harmon and King, 1985).

One of the goals of the expert system is to determine solvency trend. This section of the knowledge base, after analyzing the financial information will draw four conclusions. They are:

1. An assessment of overall financial position.
2. An assessment of the farms credit risk.
3. An assessment of the farms short term solvency.
4. A prediction of future farm financial solvency.

The search tree in figure 1 represents a portion of the knowledge base that predicts the solvency of the farm. The center branch of the tree (the only one shown that reaches a goal) represents only 5 rules of the total 256 rules contained in the first prototype system. This is followed by a decision rule example in figure 2., written both with symbols in set theory and using Insight Two syntax or object=>attribute=>value clauses. An example of the printed output from the expert system after solvency of the farm is predicted is illustrated in figure 3.

The rule illustrated in figure 1 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 with 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 2.

FIGURE 2 DECISION RULE EXAMPLE : FIRM CLASSIFICATION

	RULE	To examine 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 a poor financial position
H)	AND	PRINT poorest position
I)	AND	Solvency trend determined

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. A farm with debt asset ratio above 70%, with an unfavorable trend in equity, interest and rent ratio above 25%, and negative net income plus withdrawals will yield the conclusion "This is a poor financial position."

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 that are conclusions to other rules. For example the clause "Operation of farm is eroding net worth" is a scenario where equity trend is down while asset value trend is up.

The clause "poorest position" located after the key word PRINT in figure 2 will print the clause shown in figure 3 for the user. This is an example of how the expert system provides printed output tailored to the specific circumstances found in the financial variables. All possible combinations of the relevant financial variables are represented in this manner.

FIGURE 3 EXAMPLE OF MODEL OUTPUT

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. The income statement analyzed 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 expert system prototype categorized farms as good, moderate or poor based largely upon the debt asset ratio. With farms over 70% rated poor, farms under 40% rated good, and the farms in between rated moderate. Credit risk and short term solvency were determined in the same manner. Long term solvency was based upon the firms category then increased or decreased based upon the farms 4 year trend in equity. When all other financial factors were at the opposite extremes from the debt asset ratio value, the farm would be placed in the next highest or lowest category.

This expert system was designed without the use of certainty factors. Conclusions were reached with 100% certainty in the knowledge base. This does not mean that conclusions reached by the knowledge base are definitive assessments as was discussed earlier. The uncertainty is incorporated in to the language used to write the conclusions regarding the case farm.

VALIDATION AND TESTING

The first version of the expert system was comprised of 256 rules. As part of the validation process and as a means of eliciting additional information from experts, this section of the model was tested against three loan officers. The purpose of this procedure was to test the hypothesis that the opinion regarding the financial position of a farm business using an expert system would not be different from that of another loan officer. The results of this test were encouraging and provided a means for uncovering ways to improve on the rules in the knowledge base.

The process of obtaining expertise from experts using conventional knowledge engineering techniques is not an easy one (Michalski, 1980) . Experts are not always able to articulate their decision making processes. Also experts may not be confident in their expertise which was illustrated during the knowledge engineering stage of this project.

An interesting result of performing this test was the accumulation of more knowledge. The testing turned out to be more of a knowledge engineering exercise than a model validation exercise. The interviews with experts illustrated some shortcomings in the knowledge base that arose from the inability to elicit expertise during the earlier knowledge engineering process. The following is a discussion of the problems that surfaced as a result of this test and how the model was adjusted to compensate for this shortcoming.

THE REVISED MODEL

The disagreement between the expert system and experts during the first test was focussed around the same eleven case farms for each loan officer. These farms were for the most part near the borderlines between different categories of firm position. Management criteria were incorporated in to the rules to assist in screening the borderline farms.

MODEL CHANGES

1. In their present form the decision rules do not look at magnitudes for net income, equity, or withdrawals. Rules were added to highlight cases with unusual circumstances to prevent errors in the categorization process. For example a case suffering a large capital loss during one period is noted by the knowledge base.

2. Another obvious weakness of the expert system comes from the dominant role played by the debt asset ratio in many of the decisions. The rules were adjusted so that farms in border areas would be screened through two additional sets of rules. First using rules to examine other financial factors and second rules that analyze farm management factors. Farm management factors were brought to bear on this process by constructing a composite management score based upon the weighted values for production and various cost relationships.

   This management score is calculated as a weighted average of production per cow, purchased feed costs and other selected expenditures. The weights were obtained according to the importance of an item to the farm business (proportion to total farm expenditures).

3. The model at this stage did not distinguish between firm position, credit risk and short term solvency. Only with long term solvency did the model use other rules to make its prediction. The predictions and assessments of the expert system were therefore reduced to an assessment of firm position and a prediction of long term solvency.

The modification of the rules in the knowledge base resulted in the recategorization of two case farms. One farm was moved from moderate to poor based upon financial criteria and the other was moved from poor to moderate based upon management criteria.

The test results are shown below from the revised expert system model. Results with eight other loan officers illustrating the level of agreement between the loan officers the expert system are shown in table 1.

Table 1. Measure of Agreement among expert system and loan officers. Second test.

expert system	69%
loan officer #1	64%
loan officer #2	68%
loan officer #3	69%
loan officer #4	65%
loan officer #5	61%
loan officer #6	65%
loan officer #7	68%
loan officer #8	72%
average agreement	67%

Results in table 1 illustrate that the expert system achieved the same level of agreement as the loan officers did with each other.

Evidence that the expert system is a good tool for the purpose of screening financial documents. This table also illustrates that for over 30% of the cases analyzed, the loan officers were not in agreement in their predictions and assessments. This fairly high level of inconsistency in their decision making would be eliminated with a deterministic model such as an expert system. By removing inconsistencies in loan officer decisions the credit institutions would insure that institutional policies were better employed. Loan officers would have a method of checking their decisions against the expert system. This would result in a better documentation of decisions. The more consistent loan officer decisions could also help to improve customer relations.

A properly validated expert system would reduce large variability in decision making by providing the loan officer with a consistent method of screening financial documents as a means of supporting their own decisions.

A better test of the expert system will be a comparison of the predictions from the model with the future outcomes of the case farms. By tracking the case farms over time, we will be able to determine if the predictions of the model correctly used the information analyzed.

CONCLUSIONS

The purpose of the expert system discussed in this paper was to provide loan officers with a method of screening loans in a portfolio to select those farms that require further analysis. The rules in the knowledge base are deterministic which leads to a consistent method of screening case farms in a portfolio.

This research project confirms the difficulty in using conventional knowledge engineering techniques to elicit expertise. Other approaches were developed such as prototyping and informal testing of the knowledge base to elicit expertise for the expert system knowledge base. These methods resulted in capturing some of the deep expertise that experts may have trouble articulating.

Results of this research indicate that the expert system made decisions that were consistent with those of loan officers. The results also indicate that a properly validated expert system would make more consistent decisions than human experts. This research project confirms that expert systems can be a useful method of solving certain classes of problems (Waterman, 1986). The results also signify that expert systems continue to show potential as important tools for analyzing financial documents.

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