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Agricultural Loan Evaluation With Discriminant Analysis

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FOREWORD

Credit institutions which finance farming operations are confronted with growing problems in providing adequate capital for farmer borrowers and in evaluating loan applications. Both the magnitude and complexity of agricultural loans have increased tremendously in recent years.

The Federal Intermediate Credit Bank of St. Louis and the Agricultural Economics Department of the University of Missouri-Columbia have been engaged in cooperative research in farm financial management for several years. Selected Production Credit Associations in the Sixth Farm Credit District (including Arkansas, Illinois, and Missouri) have played a key role in these studies.

One aspect of the research project has been the development of a computerized credit scoring model which would save time and costs in making credit examinations in the three-state area. The over-all purpose of the study was to identify the most significant variables affecting financial management performance; to determine the appropriate weights to assign to each; and to develop a computerized model which would sort and classify loans in a manner similar to that done personally by a trained credit analyst. Several kinds of analytical models were investigated but one using discriminant analysis proved to be the most useful and reliable.

The purpose of this publication is to describe the development of the computerized model and to explain how it is being used in the Sixth Farm Credit District in making credit examinations for PCA borrowers.

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Agricultural Loan Evaluation With Discriminant Analysis

R. BRUCE JOHNSON AND ALBERT R. HAGAN*

INTRODUCTION

Periodic evaluation of agricultural loans is necessary to ascertain the financial position and progress of borrowers. An accurate assessment of each borrower's financial performance provides lenders a basis for either extending or restricting the present line of credit and for determining the amount and kind of supervision needed.

Credit analysis is concerned primarily with examination of the financial condition of borrowers with either poor or less than average financial performance. However, considerable time is required for a credit analyst to audit a borrower's loan records and to determine accurately his financial performance rating. For example, credit analysts of the Federal Intermediate Credit Bank of St. Louis estimate that 50 percent of their time is required to determine the financial performance of the problem, vulnerable, and loss loans.[1] Yet loans in these groups comprise only 12 percent of the total loans made by Production Credit Associations in Missouri, Illinois, and Arkansas (2).

Both farm operators and credit institutions would benefit from a more efficient use of credit resources if a simple mathematical model could be incorporated to analyze all loan applications. More specifically, combining a quantitative model with the speed and accuracy of a digital computer to analyze loans would result in several benefits. First, there would be a significant reduction in the man-hours required for trained analysts to classify loans into good (acceptable) and problem loan groups. Second, this savings in man-hours could be utilized in a more thorough analysis of the problem loans. Third, there could be a more frequent check on the quality of credit and direction of financial performance.

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[1]The loan classification criteria used by the St. Louis FICB is presented in Appendix A.

THE LINEAR DISCRIMINANT MODEL

Discriminant analysis is a statistical tool which lends itself to classifying items into predetermined populations. The linear discriminant model has been used previously to quantify the credit rating of both consumer and agricultural loans (1,4,5). The technique of discriminant analysis is based on the assumption that a linear function $Y = B_1X_1 + B_2X_2 + \ldots + B_nX_n$ exists which will distinguish between elements of a population. The discriminant model utilizes coefficients $B_1, B_2, \ldots, B_n$ chosen in such a way that the ratio of between-groups sum of squares is maximized. Therefore, the index Y represents the optimum discriminator between the groups. Factors $X_1 \ldots X_n$ represent the quantifiable characteristics of the loans.

With regard to the actual mathematic description of the model, let the n factors $X_1, X_2, \ldots, X_n$ be the n characteristics of the agricultural loan. If there are h categories of loans, each category having M_k, $(j = 1, 2, \ldots h)$ individual loans, then the tuple

$$(X_{1_{j,k}}; X_{2_{j,k}}; X_{3_{j,k}}; \ldots; X_{n_{j,k}})$$

represents the data vector for loan k in category j.

Detailed theoretical and computational procedures for determining the discriminate coefficients are readily available (3). However, some important facets of the typical analysis are outlined below:

(a) Assumption: the data vector is assumed to be multivariate-normal in distribution to facilitate tests of hypotheses and classification routines. The covariance structure among the variables in the data vector is assumed to be constant within each loan category.

(b) The discriminate coefficients are chosen to maximize the ratio of among to within groups variance in discriminate scores. These coefficients are dimensionless and their ratio is important, not their value.

The expected proportion of correct classifications is diagramed in Figure 1. The diagram denotes the situation where there are two populations and only one variable, i.e., $M = 2$ and $n = 1$. The figure assumes that the samples are large enough that all the population parameters can be regarded as known.

Since the variance of Y (which is assumed to be the same in the two populations) and the population means are known, the likelihood of an observation being classified into either Population 1 or Population 2 is determined by consulting a table of normal distributions. The probabilities of an observation receiving a classification into either Population 1 or Population 2 are equal at Y_c. One would classify all cases where $Y > Y_c$ in Population 2. Conversely, all observations where $Y < Y_c$ would be classified in Population 1. The shaded area in Figure 1 represents the expected proportion of misclassified cases.

The Cut-Off Point

If one assumed that the two kinds of errors (classifying an acceptable loan into the problem group and classifying a problem loan as acceptable) are of

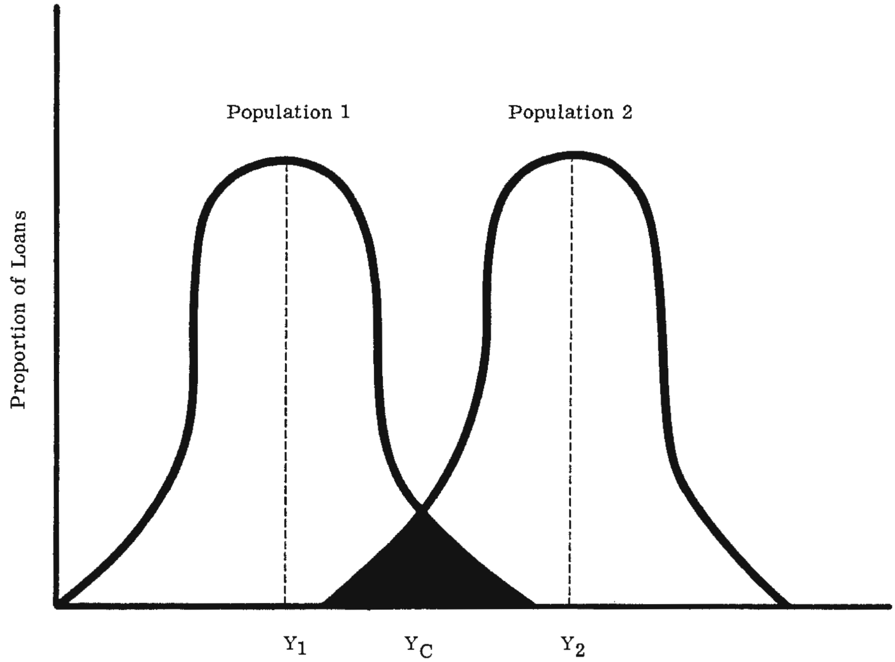

Figure 1. Classification for two populations and one variable: Population parameters known.

equal significance, the cut-off point would be Y_c on Figure 1. This point can be determined algebraically:

$$Y_C = \frac{\sigma_A \bar{Y}_P + \sigma_P \bar{Y}_A}{\sigma_A + \sigma_P}$$

where

σ_A = the standard deviation of the Y-values for the acceptable loan group
σ_P = the standard deviation of the Y-values for the problem loan group
$\bar{Y}_A$ = the mean Y value of the acceptable loan group
$\bar{Y}_P$ = the mean Y value for the problem loan group.

After determining the cut-off point (Y_c) a Z statistic[2] can be computed for both $\bar{Y}_A$ and $\bar{Y}_P$. The Z statistic for $\bar{Y}_A$ is determined according to the following formula:

$$Z_A = \frac{Y_C - \bar{Y}_A}{\sigma_A}$$

Similarly, a Z statistic can be computed for $\bar{Y}_P$:

$$Z_P = \frac{Y_C - \bar{Y}_P}{\sigma_P}$$

[2]The Z statistic is distributed almost normally with variance $\sigma_Z^2 = \frac{1}{n-3}$.

The percent of acceptable and problem loans which might be misclassified can be determined by referring to a Z table.

The F-Test

The null hypothesis that the discriminant function does not discriminate between acceptable and problem loans can be tested by an analysis of the variance of Y. The F value is computed from the following ratio:

$$F = \frac{\text{Sum of Squares / n (between loan groups)}}{\text{Sum of Squares / } M_A + M_P \text{ - n - 1 (within loan groups)}}$$

where:

n $=$ number of X's

M_A = number of acceptable loans

M_P = number of problem loans

Given the appropriate probability level, if the computed value of F is greater than the tabled value of F with n and $M_A + M_P - n - 1$ degrees of freedom, the discriminant function effectively discriminates between the two groups of loans.

Data

Data for the study were collected from loan applications of borrowers at three Production Credit Associations located in central and northwestern Missouri. The president of each association provided a list of all borrowers who had current loans from the PCA. Each loan had been examined recently (by credit analysts of the Federal Intermediate Credit Bank of St. Louis) and classified as problem or acceptable. Data used in the analysis were from 204 acceptable and 68 problem loans.

Selection of Variables

Heeding the advice and suggestions of the presidents of three Production Credit Associations, the credit analysts of the Federal Intermediate Credit Bank of St. Louis and other FICB agricultural credit personnel, a decision was made to measure financial performance of production credit borrowers by using various ratios of selected financial data.

Several variables were considered for analysis and subsequent inclusion in the discriminant model. Following extensive testing and evaluation of various measures of financial performance, three variables were selected for use in the final model.

X_1 Repayment index. The amount of the loan actually repaid each year plus the value of marketable products not sold during the year was expressed as a percentage of the amount expected to be repaid. This index was computed for the current year only.

X_2 Current ratio. The ratio of current assets to current liabilities computed for the most recent financial statement.

X_3 Total debts as a percent of total assets. Total debts divided by total assets for the most recent financial statement.

Turning now to an examination of financial ratios computed for each group of sample borrowers, data in Table 1 reveal some sizeable differences in the values of the three measures of financial strength of the 272 sample borrowers.

TABLE 1--MEAN VALUES OF VARIABLES INCLUDED IN THE LINEAR DISCRIMINANT FUNCTION, ACCEPTABLE AND PROBLEM LOANS, PRODUCTION CREDIT ASSOCIATIONS, MISSOURI, 1969

Variable	Loan Classification Group		Difference
	Acceptable	Problem	Between Groups
Repayment index	1.12	0.66	0.46
Current assets/current debts	5.24	1.48	3.76
Total debts/total assets	0.27	0.56	-0.29

The ratio of repayment made (plus marketable crops, livestock, and produce) to repayment expected is a measure of the repayment performance of the borrower. The mean values for this ratio clearly indicate that the acceptable loan group has a repayment performance significantly higher than the problem loan group. The difference for the repayment index between loan groups is .46.

The current ratio is often referred to as a measure of a borrower's liquidity. Data in Table 1 show the acceptable borrowers are in a much more liquid position than those in the problem loan group. The numerical difference in the average current ratio between the acceptable and problem loan groups is 3.76.

The debt-asset ratio is a measure of longer term financial strength. Since the debts comprise only 27 percent of the assets of the acceptable group and since the corresponding figure for the problem loan group is 56 percent, it appears that borrowers in the acceptable loan group are in much stronger financial position than those in the problem loan group.

Development of the Discriminant Model

The discriminant model was developed on the basis of the application of discriminant analysis to data from 204 acceptable loans and 68 problem loans. Applying the estimated coefficients, the specific linear discriminant function for the 272 loan observations was:

$$Y = 0.2525\ X_1 + 0.0091\ X_2 - 0.04502\ X_3$$

where:

X_1 = one year repayment index

X_2 = the ratio of current assets to current debts

X_3 = the ratio of total debts to total assets

To test the null hypothesis that the discriminant function does not discriminate between acceptable and problem loans, analysis of the variance of Y was conducted. As illustrated in Table 2, the calculated F value was 128.65. Referring

TABLE 2--ANALYSIS OF VARIANCE FOR DISCRIMINANT FUNCTION, ACCEPTABLE AND PROBLEM LOANS, PRODUCTION CREDIT ASSOCIATIONS, MISSOURI, 1969

Source	d.f.	S.S.	M.S.	F
Between Groups	3	.040528	.013509	128.65*
Within Groups	268	.028190	.000105	

*F-value significant at .01 level of significance.

to the F table with $n=3$, $M_A=204$, and $M_P=68$, the function was found to be significant at the .01 level of significance. Therefore, we reject the null hypothesis that the discriminant function does not discriminate between the acceptable and problem loan groups.

The means, variances, and standard deviations were computed for the discriminant functions of the two borrower groups. Values of these estimated parameters are illustrated in Table 3. These estimates, based on large samples, will be treated as population parameters in the discussion that follows.

TABLE 3--THE MEANS, VARIANCES, AND STANDARD DEVIATIONS FOR THE DISCRIMINANT MODEL, ACCEPTABLE AND PROBLEM LOANS, PRODUCTION CREDIT ASSOCIATIONS, MISSOURI, 1969

Loan Classification Group	Sample Size	Mean Discriminant Value	Variance	Standard Deviation
Acceptable	204	0.02075	0.00011	0.01050
Problem	68	-0.00744	0.00009	0.00931

To classify agricultural loans with the discriminant model, a critical value for Y must be established. If we assume that the two kinds of errors in misclassification are of equal significance, the critical or cut-off value can be calculated by the previously discussed method where

$$Y_C = \frac{\sigma_A \bar{Y}_P + \sigma_P \bar{Y}_A}{\sigma_A + \sigma_P}$$

$$= \frac{(.01050)\ (-.00744) + (.00931)\ (.02075)}{(.01050) + (.00931)} = .00581$$

After calculating this cut-off point, Z_A and Z_P would be

$$Z_A = \frac{Y_C - \bar{Y}_A}{\sigma_A} = \frac{(.00581) - (.02075)}{(.01050)} = -1.42$$

$$Z_P = \frac{Y_C - \bar{Y}_P}{\sigma_P} = \frac{(.00581) - (0.00744)}{(.00931)} = 1.42$$

Referring to a table of values for "cumulative normal frequency distribution," the computed Z values indicate that the discriminant function would correctly classify 92 percent of the borrowers.

When applying the cut-off score to computed Y values for a group of agricultural loans, those loans with Y values equal to or greater than .00581 would be classified acceptable while those with Y values less than .00581 would be classified into the problem group. There is an 8 percent probability that loans in each group would be misclassified.

The method of loan classification would be suitable if the consequences of the two possible classification errors were of equal significance. However, since the computer credit scoring model will replace the credit analysts' personal examination and since all problem loans need to be reviewed annually, a more precise classification scheme is needed. Thus, the probability of misclassifying problem loans into the acceptable loan group must be reduced to a more tolerable level. Credit analysts of the FICB indicated a 1 percent misclassification level could be tolerated. Therefore, a cut-off score which has a .01 probability for misclassification of problem loans was calculated. This alternative cut-off score will be termed the critical Y value (CV) for classifying loans.

Consulting a table of cumulative normal frequency distribution, the appropriate critical value was derived through the following calculation:

$$Y_{CV} = \bar{Y}_P + (Z)\sigma_P$$

where:

Y_{CV} = critical Y value
$\bar{Y}_P$ = mean Y value for the problem loan group
Z = standard measure
σ_P = standard deviation of $\bar{Y}_P$

The appropriate value of Z which allows a 1 percent misclassification tolerance was 2.33. Thus, multiplying the standard measure times the standard deviation of the sample mean (σ_P) and adding this product to the sample mean ($\bar{Y}_P$) results in a critical Y value. Assuming the sample mean ($\bar{Y}_P$) score approximates the population mean, there is only one chance out of 100 of misclassifying a problem loan into the acceptable loan group.

To test the discriminant function on borrowers' loan data, the following critical Y value was calculated:

$$Y_{CV} = 0.00744 + 2.33\ (.00931)$$
$$= .01425$$

Thus, all loans receiving Y scores to or greater than .01425 were classified into the acceptable loan group. Conversely, loans with Y scores less than the CV were categorized into the problem loan group.

Illustration of the Discriminant Model

Utilization of the discriminant model developed in this study can be illustrated by the following hypothetical example. Suppose an individual borrower has the following financial data on his loan application form for the current year:

Repayment made on principal	\$ 30,000
Expected repayment on principal	\$ 30,000
Current assets	\$ 60,000
Current debts	\$ 20,000
Total assets	\$200,000
Total debts	\$ 50,000

From the data listed above, the three variables can be calculated

$$X_1 = \text{Repayment Index} = \frac{\$30,000}{\$30,000} = 1.00$$

$$X_2 = \text{Current Ratio} = \frac{\$60,000}{\$20,000} = 3.00$$

$$X_3 = \text{Debt-Asset Ratio} = \frac{\$50,000}{\$200,000} = .25$$

Substituting these values into the estimated discriminant function, a Y value (credit score) is computed

$$Y_k = .02525\ (1.00) + .0091\ (3.00) - .04502\ (.25)$$
$$= .04130$$

Since Y_k is greater than the CV (.01425) this loan would be classified acceptable and, hence, not subjected to examination by a credit analyst.

Application of the Discriminant Model

In an effort to verify the effectiveness of the discriminant function, the coefficients were applied to appropriate data from borrowers of the Mississippi Valley Production Credit Association, Pittsfield, Ill. A total of 378 loans were selected for analysis. Three hundred of the loans were classified acceptable, 24 loans were rated acceptable with significant credit weaknesses, 52 loans were classified as problem loans, and two loans received a classification as loss loans (Table 4).

TABLE 4--NUMBER OF PRODUCTION CREDIT LOANS BY LOAN CLASSIFICATION GROUP, MISSISSIPPI VALLEY PRODUCTION CREDIT ASSOCIATION, PITTSFIELD, ILLINOIS, 1970

Loan Classification Group	Number of Loans
Acceptable	300
Acceptable with significant credit weaknesses	24
Problem	52
Loss	2
Total Loans	378

Since FICB credit analysts would like to examine all loans with a credit rating which is less than fully acceptable, all acceptable loans with significant credit weaknesses, problem loans, and loss loans were categorized into the problem loan group. Thus, for examination purposes, the Missouri Valley PCA sample consisted of 300 acceptable and 78 problem loans.

When coefficients of the discriminant model were applied to the Mississippi Valley PCA borrowers' financial data, the results (Table 5) were encouraging. One hundred fifty-six (52.0 percent) of the 300 acceptable loans were classified accordingly. In addition, only one of the 24 acceptable loans with significant credit weaknesses was classified into the acceptable loan group. None of the 54 problem and loss loans were misclassified. From an aggregate point of view, 61.6 percent of the acceptable and problem loans were accurately categorized into their respective loan groups.

TABLE 5--NUMBER OF ACCEPTABLE AND PROBLEM LOANS CLASSIFIED BY FICB CREDIT ANALYSTS AND THE LINEAR DISCRIMINANT MODEL, MISSISSIPPI VALLEY PRODUCTION CREDIT ASSOCIATION, PITTSFIELD, ILLINOIS, 1970

Method of Classification	Loan Classification Group	
	Acceptable	Problem
Credit analyst	300	78
Discriminant function	156	77

SUMMARY

Agricultural lending institutions are faced with a task of periodically evaluating personal and financial attributes of their borrowers. This examination is necessary in order to determine the present quality of the loans and to assess the current financial position of each borrower. Moreover, analysis of each borrower's financial performance establishes a basis for extending, limiting or withdrawing the present line of credit and for determining the amount and kind of supervision needed.

Presently, most analyses of borrowers' financial positions are conducted via personal examination of individual credit files by either trained credit analysts or loan officers of various lending institutions. The initial objective of credit examination is to determine the current financial condition of each borrower and classify his loan into one of two possible categories: acceptable loans (high quality loans requiring only normal supervision) or problem loans (weak loans possessing serious credit deficiencies and requiring more than normal supervision).

This study was concerned with the utilization of a statistical technique—discriminant analysis—to classify agricultural loans. To develop a discriminant function, data from two groups of loans, which had been classified previously by credit analysts as acceptable or problem, were required. By submitting the two groups of data to discriminant analysis, a linear discriminant function was estimated. To classify a loan into its appropriate category, a critical value score was calculated. Loans with discriminant values equal to or greater than the critical value were classified as acceptable while loans with values less than the critical value were classified into the problem loan group.

Three variables were included in the discriminant model: repayment index, current assets to current liabilities ratio, and total liabilities to total assets ratio. Data from two groups of loans were obtained from borrowers of Production Credit Associations in central and northwest Missouri.

Obviously, the contribution of this model to the field of credit examination depended on its ability to classify agricultural loans accurately. In view of this fact, the discriminant function was tested on loans from outside the original sample. Coefficients of the model were applied to appropriate financial data secured from loans of 378 borrowers of the Mississippi Valley Production Credit Association. Test results indicated the model classified correctly 61.9 percent of the loans. Moreover, no problem loans were incorrectly classified as acceptable.

Following intensive testing of the discriminant function on loan data of borrowers of Production Credit Associations in Missouri, Illinois, and Arkansas, the Federal Intermediate Credit Bank of St. Louis asked for and received approval from the Farm Credit Administration to utilize the model for credit scoring Production Credit Association loans in the Sixth Farm Credit District. This program was implemented in October, 1971.

Staff members of the St. Louis FICB developed detailed instructions for use by PCA members for the credit scoring program, using the computer model. A "Credit Scoring Form" was prepared for transmitting pertinent data for each

borrower included in the computerized program. (A reference copy is included as Appendix B.) Some loans in each association are omitted from the computerized scoring and are evaluated personally by credit representatives (examiners) during visits to the association. These omissions include extremely large loans, small loans of a routine nature, and special loans with unique features. Actually, the purpose is to identify and classify a large percentage of the "acceptable" loans in order to achieve the following benefits, as explained in a memorandum to the PCA presidents.

1. Reduce credit examination costs.
2. Reduce the man hours needed to classify the obviously acceptable loans, thereby allowing more time for loans that require more attention and in-depth analysis.
3. Create greater opportunity for credit representatives to assist the associations in credit training and specialized loan handling.
4. Provide credit scoring index information that will be useful to the PCA's in their credit administration.

Staff members of the FICB report that these objectives are being achieved and they are quite pleased with the performance of the new credit scoring program. Since instituting the program, credit representatives in the three-state district now have more time to assist association personnel with the improvement of lending procedures.

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APPENDIX A
LOAN CLASSIFICATIONS OF THE FEDERAL INTERMEDIATE CREDIT BANK OF ST. LOUIS

The present loan classification scheme used by the St. Louis FICB credit analysts includes four classes; namely, acceptable loans, problem loans, vulnerable loans, and loss loans.

The acceptable loan group includes loans of highest quality ranging down to and including those having significant credit weaknesses.

> This classification includes a wide range of loan quality. Member equity in relation to credit extended must be adequate to protect the association from more than normal risk. Management ability and total income must be adequate over a reasonable period of time to assure repayment performance and to maintain or improve the loan quality. These loans will require only normal supervision.[1]

Problem loans are defined as those loans possessing serious credit weaknesses. These loans require more than normal supervision but are believed to be collectible in full.

> These are weak loans having serious credit deficiencies. Predominant factors in these loans will be questionable integrity; low equity position creating more than normal risk; substandard performance; unwise use of credit; adverse trends; and faulty management, which individually or collectively result in serious credit weakness. Such loans are believed fully collectible, but require more than normal supervision either to improve performance to acceptable standards or to achieve planned liquidation.[2]

High risk loans that are still considered to be collectible in full are defined as vulnerable loans. These loans have a high probability of loss should the sources available for repayment fail to materialize.

> These are very weak loans having critical credit deficiencies. These loans should be collectible provided the association follows prudent repayment planned from normal or other sources of liquidation. However, if collection from these sources does not materialize, the probability of loss exists. Usually these loans are inadequately secured by primary collateral, and the secondary collateral or other available resources, if any, may represent an uncertain or doubtful source of final liquidation.[3]

The fourth category is labeled loss loans. This classification includes all loans that are not collectible and loans on which any part is concluded to be uncollectible.

> These loans represent cases in which it appears that all or a portion of the borrower's total indebtedness to the association, including any previous partial charge-off, will not be collected in full.[4]

[1]Farm Credit Administration, *Manual for Credit Examination of Production Credit Associations,* Revised Edition (Washington U.S. Government Printing Office, 1969), pp. 14-15.
[2]*Ibid.* [3]*Ibid.* [4]*Ibid.*

APPENDIX B
CREDIT SCORING FORM

PCA No.	Member No.

(1)____________________________________
Member's Name

(DO NOT INCLUDE CENTS)

(2) Value of Current Assests $____________

(3) Amount of Current Debts $____________

(4) Amount of Total Debts $____________

(5) Value of Total Assets $____________

(6) a. Repayment Made During Prior Loan Year $____________

b. Marketable Inventory on Hand at Loan Renewal Date $____________

(7) Repayment Anticipated During Prior Loan Year $____________

(8) a. Check if Co-Signed Loan (exclusive of spouse) ☐

b. Check if Corporation Loan ☐

(9) Check if Questionable Moral Risk ☐

(10) Circle (ONE ONLY) Major Enterprise by Code

CODE	ENTERPRISE	CODE	ENTERPRISE
01	Cash Crop	06	Feeder Cattle
02	Broiler	07	Dairy
03	Layer	08	Hog
04	Turkey	09	General Purpose
05	Cow-calf	10	Other

(11) Date of Financial Statement____________ Completed By____________ / / 197_