Application of the CART Method to Determine the Amount of Credit Limit in KIS Syariah Cooperatives

Lesia Fatma Ginoga1*, Asty Khairi Inayah Syahwani1, Dahri Tanjung2, Resti Jayeng Ramadhanti1, Dona Siregar3, and Novi Rosyanti1

1Accounting Study Program, College of Vocational Studies IPB University, Bogor 16128, Indonesia
2Management of Agribusiness Study Program, College of Vocational Studies IPB University, Bogor 16128, Indonesia
3Department of Business, The State University of New York, Suny Oneonta, New York, United States

Abstract. For the purpose of giving credit, financial institutions conduct analysis. The credit limit must be changed based on the customer's capacity to pay. A crucial task that must be completed is determining the limit by looking at a lot of factors, particularly the financial one, which includes cooperatives that provide microloans. One of them, Koperasi Simpan Pinjam dan Pembiayaan Syariah Kebajikan Ikamatabagsel Sejahtera (KSPPS KIS), does not strictly rely the determination of the credit limit on analysis, which causes credit issues to continue to arise. The percentage of cooperative consumers with the biggest current credit status has a minimum limit of IDR 2,200,000, with a duration of less than 50 weeks, according to the findings of an analysis utilizing the CART method and data from 173 customers of the KIS Cooperative. This section serves as a gauge for the credit limit's size at the time of analysis. This demonstrates that a time of less than 50 weeks will result in a lower level of non-current credit status than a period of more than 50 weeks and other variables such as the ratio of expenses, the value of costs, and income. Future studies should be able to include more variables that cooperatives can evaluate when deciding credit limits.

1 Introduction

Financing institutions in channeling funds in the form of credit or loans, must analyze and determine the amount of credit or limit according to the ability of the customer. According to [15] when a banker gives a loan to an individual or company, the banker needs an evaluation in the form of a credit rating, which helps determine the existing or potential risks of the loan given, because the credit rating is very important. First, determine the risks faced by banks when extending credit to individuals or companies. Second, anticipate loan repayment because the bank already knows the readiness of the borrower's

* Corresponding author: lesiafatma1@apps.ipb.ac.id

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).
business cash flow analysis. The third, knowledge of the type of credit, the number of credits and the credit period required for the borrower's business, and knowledge of the debtor's ability and willingness to pay.

In order to depict the dynamic solution relating to the updated credit historical data, reinforcement learning techniques are used to optimize this credit risk-based pricing. The profit optimization model takes into a view factors, including credit ratings, tenor, credit pricing (or rate for credit applicants), and limit [16] The limit credit is a mechanism used in financial planning to enhance earnings; the limit will be expanded to its greatest size [5]. Determination of the limit credit, the maximum credit that will be given to customers resulting from an analysis of the financial aspect, is a critical issue because the amount of credit and the provision of funds provided by financial institutions, especially cooperatives, to customers must be appropriate and according to customer needs.

According to [10] the amount of credit given is basically in accordance with the needs of prospective customers, because the amount of credit and the timing of terminating credit to customers is not appropriate which can lead to over-financing or under-financing. In addition, if there is an error in determining the limit, it will also affect credit returns from customers. Loan repayments that are not as scheduled will have an impact on credit quality. According to [14] credit quality is based on the collectibility or accuracy of principal and interest payments, as well as the ability of the borrower. Delays in returning credit will also add to non-performing loans to financial institutions or also called Non-Performing Loans [12]. According to [7] Non-Performing Loans are loans that have been disbursed by banks, and customers cannot make payments or make installments according to the agreement signed by the bank and the customer. The higher the Non-Performing Loan, the worse the credit quality, which causes the number of non-performing loans to increase [3]. Koperasi Simpan Pinjam dan Pembiayaan Syariah Kebajikan Ikamatbagse1 Sejahtera (KSPPS KIS) in determining the credit limit has not been based on a strict analysis, resulting in many problem loans occurring, along with the limit data and KSPPS KIS collectibility.

![Fig. 1. Limit and quality of credit](image)

The finance is below IDR 2,000,000.00, based on the facts given. Loans with non-performing balances are slightly more prevalent than loans with active balances. Customers will earn IDR 2,000,000.00 apiece when they apply for financing at KSPPS KIS for the first time.
Non-performing loans, according to [6], are those that are delinquent on interest or principle of payments; any loans that fall below the collectibility level are regarded as inferior, uncertain, or lost. Since KSPSS KIS customers do not need to have prior business experience, it is likely that new businesses will be established in order to acquire finance. It is unable to do lending analysis in the best way feasible due to this policy. Due to the absence of historical data in financial reports and company profiles, loan analysis may be inaccurate. According to the data, a considerable number of loans (17.10%) have a value greater than IDR 2,000,000. In order to avoid over- and under-financing, optimize financing to clients, and reduce non-performing loans, it is crucial to establish the proper limit amount for each financing distribution. Determining customer segmentation will use CART so that we know which customer segmentation has good and bad risk characteristics. CART is a popular classification model that can handle both quantitative and categorical data simultaneously, the construction of decision trees reflects the separation of attributes from each characteristic involved into 'good' and 'bad' risk classes [1]. Based on the explanation above, a study was conducted with title "Application of the CART Method in Determining the Amount Amount of the Credit Limit in KIS Syariah Cooperative".

2 Method

Research methodology is an attempt to investigate and explore a problem by using scientific methods carefully and thoroughly to collect, process, analyze data and draw conclusions systematically and objectively to solve a problem or test hypotheses to obtain knowledge that is useful for human life [2]. Data Sources This research uses secondary data, namely sources that contain research results or writings published by authors who do not directly conduct research or are not the inventors of theories. Examples of secondary sources such as: reading books, textbooks, and encyclopedias [7] based on secondary data obtained as many as 173 data, obtained from the credit limit of KPPS KIS customers in 2022.

Some popular methods that have been used by some researchers are classification and regression tree (CART), Support Vector Machine (SVM), Artificial Neural Network (ANN), Multivariate Adaptive Regression Splines (MARS) [3]. Previously, researchers have used private dataset to explore credit scoring. In this credit scoring research, we explore an approach to increase the performance of our base learner algorithm. CART algorithm is chosen as a base learner, since it is one of the best algorithms that is mostly used for the classification task. Binary Particle Swarm Optimization is adopted to increase the performance of the CART algorithm. The proposed method is validated with real public credit dataset. The result shows an overall improvement of our experiment. Based on several indicators, the proposed method shows a better performance, such as accuracy, error rate, sensitivity, specific and precision [9]

According to Karliger in Abubakar [2] variable is a construct or trait that will be studied, such as education level, social status, gender, work productivity and so on. The variables in this study consist of the dependent variable (Y), commonly called the dependent variable, which is a variable that is affected or becomes a result of the existence of independent variables. The independent variables in this study consist of categorical scale collectibility, and the independent variable (X), which is commonly referred to as the independent variable, is the variable that is the cause of the change or the emergence of the dependent variable. The independent variables in this study are limit, length of loan period (in weeks), income, cost and debt burden ratio (DBR) on a numerical scale. Classification and Regression Trees (CART) is a nonparametric statistical method developed for the purposes of classification analysis, both for categorical and continuous response variables.
According to [4], Classification and Regression Trees (CART) is an algorithm from a decision tree technique also referred to as a Decision Tree. CART will produce a classification tree if the response variable has a categorical scale and will produce a regression tree if the response variable is continuous data. A classification tree is a method of repeatedly partitioning data to produce a tree composed of many nodes formed from a binary recursive sorting process.

In the construction of a CART classification tree there are three stages. First, the selection of the separator at each node aims to get a separator that able to produce a node with the highest level of homogeneity of the response variable values. The heterogeneity of a node is measured based on its maturity value.

The heterogeneity of a node is measured based on its impurity value. The method of choosing the sorter uses the impurity measure \( i(t) \), which is a measure of the heterogeneity of a class from a certain node in the classification tree that can find the optimal sorting function. The impurity measure function \( i(t) \) used is the Gini index function shown in the formula:

\[
i(t) = 1 - \sum P_j j(t) (1)
\]

with \( P(j|t) \) is the proportion of class \( j \) at the node \( t \). The sorter begins by checking the values of each explanatory variable to get the split-point which is obtained by finding the middle value of the 2 attribute values that have been sorted beforehand. Goodness of Split is an evaluation of sorting by splitting \( s \) at node \( t \) which is defined as a decrease in heterogeneity and the formula:

\[
\Delta i (s, t) = i(t) - PL i(tL) - PRL(tR) (2)
\]

with \( PL i(tL) \) is the proportion of observations from the \( t \) node to the left, \( PRL(tR) \) is the proportion of observations from the \( t \) node to the right. The best sorter is the one that gives the highest heterogeneity reduction value or impurity reduction value [1]. The tree is developed by means of the node \( t1 \), look for \( s^* \) which produces the highest impurity reduction value:

\[
\Delta i (s^*, t1) = max_{s \in S} \Delta i (s, t1)
\]

thus \( t1 \) is chosen to be \( t2 \) and \( t3 \) using \( s^* \). In the same way, the search for the best sorter is also carried out on \( t2 \) and \( t3 \) separately and so on.

Determination of Terminal Nodes A node is said to be a terminal node when a node \( t \) reaches the specified final limit so that there is no significant reduction in impurity. The \( t \) node is not split again but is used as a terminal node and the tree formation stops [1], according to the stopping rules below:

1. There are no significant response variables that show differences in the explanatory variables.
2. If the current tree reaches the specified maximum tree value, then the growth process will stop. For example, if the depth limit for the growth of a classification tree is set at 3, when the tree growth reaches a depth of 3, the growth of the classification tree will stop.
3. If the size of the child node is less than the specified minimum child node size value, or contains too few observations, the node will not be sorted. For example, the minimum child node size is set to 50, when the child node size is less than 50, the node will not be sorted.
4. Marking of Class Labels Class labels at the terminal node \( t \) are determined through the rule of the largest number.
3 Results Analysis

3.1 CART Classification Tree Analysis

Based on the classification tree formed, it produces 15 nodes consisting of 1 origin node, 2 inner nodes, and 4 terminal nodes with a tree depth of 3 and the explanatory variables included in the classification tree are income, limit, and age in Figure 2.

Fig. 2. Cooperative customer CART classification tree
The classification tree formed in Figure 1 above. The initial voter at the origin node (0) is the maximum credit (limit) given to customers, including customers who have less than a limit of < 2,200,000. The prediction accuracy of the results of the classification formed from the CART classification tree is 83.2%.

Table 1. Predictive accuracy of CART classification results.

<table>
<thead>
<tr>
<th>Observed</th>
<th>Predicted</th>
<th>Percent Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>current</td>
<td>Non-current</td>
</tr>
<tr>
<td>Current</td>
<td>125</td>
<td>13</td>
</tr>
<tr>
<td>Non-Current</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>Overall Percentage</td>
<td>88.7%</td>
<td>40.6%</td>
</tr>
</tbody>
</table>

The segmentation division of cooperative customers based on CART is as follows:

Table 2. Distribution of Customer Segmentation

<table>
<thead>
<tr>
<th>Segment</th>
<th>Cooperative Customer Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Customers with a limit of less than IDR 2,200,000</td>
</tr>
<tr>
<td>2</td>
<td>Customers with a minimum limit of IDR 2,200,000 for a period of less than 50 weeks</td>
</tr>
<tr>
<td>3</td>
<td>Customers with a minimum limit of IDR 2,200,000, a period of more than 50 weeks and a minimum cost or income proportion of 0.57</td>
</tr>
<tr>
<td>4</td>
<td>Customers with a minimum limit of IDR 2,200,000, a period of more than 50 weeks, a minimum cost or income proportion of 0.52 but less than 0.57</td>
</tr>
<tr>
<td>5</td>
<td>Customers with a minimum limit of IDR 2,200,000, a period of more than 50 weeks, the proportion of cost or income is less than 0.52 and the total cost per month is less than IDR 1,730,000</td>
</tr>
<tr>
<td>6</td>
<td>Customers with a minimum limit of IDR 2,200,000, for a period of more than 50 weeks, the proportion of cost or income is at least 0.41 but less than 0.52 and the total cost per month is at least IDR 1,730,000</td>
</tr>
<tr>
<td>7</td>
<td>Customers with a minimum limit of IDR 2,200,000, for a period of more than 50 weeks, the proportion of cost or income is below 0.41, the total cost per month is at least IDR 1,730,000, but their income is less than IDR 5,950,000</td>
</tr>
<tr>
<td>8</td>
<td>Customers with a minimum limit of IDR 2,200,000, for a period of more than 50 weeks, the proportion of cost or income is below 0.41, the total cost per month is at least IDR 1,730,000, but their income is at least IDR 5,950,000</td>
</tr>
</tbody>
</table>
The segmentation formed consists of 8 segments with different cooperative customer criteria. Based on this segmentation, the number and percentage of each cooperative customer with current and non-current status can be tabulated, with segmentation based on limit, time period and DBR. Debt burden is directly related to the concept of capital structure. Two fundamental theories in which the assumptions of a perfect capital market are weakened. One of the theories, the trade-off theory [8] assumes that companies decide on an optimal debt size based on compromise between the benefits of a tax shield and the losses due to the risk of insolvency. The second theory [13], sets the procedure for the preferred formation of financial resources in increasing order by the cost of the type of financing. The results of the analysis are as follows:

**Table 3. Distribution of Customers by Credit Status Based on Established Segments**

<table>
<thead>
<tr>
<th>Segment</th>
<th>Credit Status</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Current</td>
<td>Non-Current</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>46.7%</td>
<td>8</td>
<td>53.3%</td>
</tr>
<tr>
<td>2</td>
<td>28</td>
<td>96.6%</td>
<td>1</td>
<td>3.4%</td>
</tr>
<tr>
<td>3</td>
<td>31</td>
<td>91.2%</td>
<td>3</td>
<td>8.8%</td>
</tr>
<tr>
<td>4</td>
<td>72</td>
<td>75.8%</td>
<td>23</td>
<td>24.2%</td>
</tr>
<tr>
<td>5</td>
<td>31</td>
<td>91.2%</td>
<td>3</td>
<td>8.8%</td>
</tr>
<tr>
<td>6</td>
<td>13</td>
<td>92.9%</td>
<td>1</td>
<td>7.1%</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>25.0%</td>
<td>6</td>
<td>75.0%</td>
</tr>
<tr>
<td>8</td>
<td>23</td>
<td>76.7%</td>
<td>7</td>
<td>23.3%</td>
</tr>
</tbody>
</table>

**3.2 Results Analysis**

**3.2.1 Segment 1.**

Customers with a limit of less than IDR 2,200,000.00 have a current percentage of 46.7% and 53.3% of substandard. Substandard status on this criterion exceeds 50%, this is due to credit disbursement with a credit limit of less than IDR 2,200,000 is the first financing for cooperative customers. In the credit analysis, the cooperative allows customers who are just about to build their business to receive credit, so that in analyzing credit, the cooperative does not have business data and the customer's financial history. In the absence of previous data, the cooperative cannot mitigate the risk of default from the beginning of the analysis. Customers with a limit more than or equal to IDR 2,000,000.00 has a current percentage of 82.9% and 17.1% non-current. Customers on this criterion are customers who have previously financed KIS Cooperatives, whether financing 1 or more. So that on this criterion the cooperative can analyze it well because there is customer business data as well as customer financial historical data.
3.2.2 Segment 2.

Customers with a minimum limit of IDR 2,200,000 for a period of less than 50 weeks. In this criterion, customers with a period less than 50 weeks have a greater current percentage of 96.5%, while those with more than 50 weeks are 79.8%. This is possible because with a longer payment period, the awareness of customers to pay for their credit decreases and most cooperative customers take credit that more than or equal 50 days as many as 129 customers, while those that less than 50 days are as many as 29 customers.

3.2.3 Segment 3

Customers with a minimum limit of IDR 2,200,000 a period of more than 50 weeks and a minimum cost or income proportion of 0.57. Total customers on the Criteria are 31 customers with a percentage of 91.2% current and 8.8% non-current, cooperative customer awareness in making installment payments is very good even though the Debt Burden Ratio (DBR) is close to a proportional value of 65%.

3.2.4 Segment 4.

Customers with a minimum limit of IDR 2,200,000 a period of more than 50 weeks, a minimum cost or income proportion of 0.52 but less than 0.57. Customers on this criterion are more numerous than customers who have a DBR more than or equal to 0.57 as many as 95 customers. The presentation of customer status is 75.8% Current and 24.2% non-current. This is due to the lack of awareness of customers in installment payments, and the criteria for cooperatives are disbursing more credit. The cooperative hopes that with a low DBR, customers can pay their installments in accordance with the credit agreement.

3.2.5 Segment 5.

Customers with a minimum limit of IDR 2,200,000 a period of more than 50 weeks, the proportion of cost or income is less than 0.52 and the total cost per month is less than IDR 1,730,000.-. The percentage is 91.2% and non-current is 8.8%, the large current percentage is due to the low dbr and the living expenses incurred by the customer are very minimal, so the ability to pay the customer's installments is very large.

3.2.6 Segment 6.

Customers with a minimum limit of IDR 2,200,000, for a period of more than 50 weeks, the proportion of cost or income is at least 0.41 but less than 0.52 and the total cost per month is at least IDR 1,730,000. The percentage is 92.9% and non-current is 7.1%, the current percentage is large because the DBR is low and the living expenses incurred by the customer are very minimal, so the ability to pay customer installments is very large.

3.2.7 Segment 7.

Customers with a minimum limit of IDR 2,200,000, for a period of more than 50 weeks, the proportion of costs or income is below 0.41, the total cost per month is at least IDR 1,730,000, but income is less than IDR 5,950,000. The percentage is 75.0% and non-current is 25.0%, the current percentage is large, this is due to the low DBR, the living
expenses incurred by customers are quite high, which is above IDR 1,730,000, and income is still quite low, so that the ability to pay customer installments is still relatively low.

3.2.8 Segment 8.

Customers with a minimum limit of IDR 2,200,000, a period of more than 50 weeks, the proportion of costs or income is below 0.41, the total value of costs per month is at least IDR 1,730,000, - , but their income is at least IDR 5,950,000. The percentage is 76.7% and non-current is 23.3%, the large current percentage is due to the low DBR, the living expenses incurred by the customer are very minimal, and the income is large enough so that the ability to pay customer installments is very large.

Based on Table 2 and Table 3, the largest percentage of cooperative customers who have current credit status is segment 2, customers with a minimum limit of IDR 2,200,000 with a period of less than 50 weeks with a percentage of 96.6%. Segment 2 can be used as a benchmark in considering the amount of the credit limit at the time of analysis. The percentage of cooperative customers who have current credit status with the addition of the variable proportion of costs/income, the total cost per month of less than IDR 1,730,000 is segment 6 with a percentage of 92.9%. As for the percentage of customers who have the largest non-current credit status, it is found in segment 7 of 75% where customers with a minimum limit of IDR 2,200,000, a period of more than 50 weeks, the proportion of cost or incomeis below 0.41, the total value the minimum monthly fee is IDR 1,730,000, but the income is less than IDR 5,950,000. In segment 7, cooperative customers experience difficulties in making payments. This can be considered by analysts in analyzing credit for customer criteria in segment 1, whether the loan amount is reduced or other options are taken, such as the loan term being extended. The importance of credit analysis in a bank, to better assess risk at the company level, in the possibility of default, this is in accordance with research [11].

3.3 Conclusion

This study discusses the importance of determining the appropriate limit size in each financing distribution so that over-financing and under-financing do not occur, so that financing to customers can be maximized and minimize non-performing loans. Determining customer segmentation will use CART so that we know which customer segmentation has good and bad risk characteristics.

The results of this study indicate several classifications of Cooperative Customer Distribution by Credit Status Based on Established Segments. The largest percentage of cooperative customers who have current credit status is segment 2, customers with a minimum limit of IDR 2,200,000, - with a period of less than 50 weeks with a percentage of 96.6%. Segment 2 can be used as a benchmark in considering the amount of the credit limit at the time of analysis. The percentage of cooperative customers who have current credit status with the addition of the variable proportion of cost or income, the total cost per month of less than IDR 1,730,000 is segment 6 with a percentage of 92.9%. As for the percentage of customers who have the largest non-current credit status, it is found in segment 7 of 75% where customers with a minimum limit of IDR 2,200,000, a period of more than 50 weeks, the proportion of costs or income is below 0.41, the total value the minimum monthly fee is IDR 1,730,000, but the income is less than IDR 5,950,000. In segment 7, can be seen that many cooperative customers experience difficulties in making payments. This can be considered by analysts in analyzing credit for customer criteria in segment 1, whether the loan amount is reduced or other options are taken, such as the loan
term being extended. The importance of credit analysis within a bank, to better assess risk at the company level, in the possibility of default.

Future research is expected to be able to add variables regarding determining the amount of credit such as the amount of customer or cooperative member intensity savings to see the development of capital in microfinance institutions.

References

3. A. M. Kuncoro, A. Jauhari, E. Widodo, Jurnal Cendekia Keuangan, 1 No. 2, 93-100 (2022)