Using the Certainty Factor to Implement a Financial Analyst Expert System in a Cooperative

Muhammad Noval Rambe, Muhammad Amin

Abstract

Cooperatives play an important role in supporting the welfare of their members through healthy, accurate, and sustainable financial management. However, the financial analysis process in cooperatives is often still done manually, which can potentially lead to delays, subjectivity, and inaccuracies in decision-making. This research aims to implement a financial analysis expert system at Koperasi Bersama using the Certainty Factor method. This method is used to accommodate the level of expert confidence in assessing financial conditions based on several indicators, such as liquidity, solvency, profitability, and cash flow. The system is built by adopting the knowledge base from experts and inference rules designed to produce a diagnosis of financial conditions and appropriate handling recommendations. The stages of the research include problem identification, knowledge gathering, system design, implementation, and system testing. The expected outcome of this research is the creation of a system that can assist cooperative managers in analysing financial conditions more quickly, consistently, and systematically. Thus, this expert system is expected to become an effective decision-making tool in improving the quality of cooperative financial management.

Keywords: *Expert System, Financial Analysis, Cooperative, Certainty Factor, Decision Making*

Muhammad Noval Rambe[1]

[1]Information Technology, Universitas Pembangunan Panca Budi, Indonesia e-mail: mbembejr@gmail.com[1]

Muhammad Amin[2]

[2]Information Technology, Universitas Pembangunan Panca Budi, Indonesia e-mail: mhdamin@dosen.pancabudi.ac.id[2]

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Introduction

Cooperatives are one of the important pillars in community economic development because they serve as a platform that supports the welfare of members through the principles of togetherness, justice, and independence. In practice, the sustainability of a cooperative is greatly influenced by the management's ability to accurately manage and analyse its financial condition. Healthy finances will reflect the cooperative's ability to run operations, meet obligations, develop the business, and maintain member trust. Therefore, financial analysis becomes a very important part of the managerial decision-making process in cooperatives. Cooperative capital can be said to act as a 'catalyst' in driving the smooth operation of cooperative businesses. The capital structure is crucial for cooperatives because the quality of the capital structure will have a direct effect on the financial position of the cooperative [1]. Cooperative work programs to achieve goals, innovate, and identify opportunities to improve member welfare. 3) driving and inhibiting factors in enhancing member welfare [2].

In reality, the financial analysis process in many cooperatives is still done manually and heavily relies on the experience or subjective judgement of the management. This condition often leads to various obstacles, such as delays in reading financial conditions, errors in interpreting data, inconsistent analysis results, and limited ability to provide accurate recommendations. If this situation continues, the cooperative may face difficulties in detecting financial problems early on, such as declining liquidity, high liability burdens, low efficiency in fund management, or potential business losses. As a result, the decisions made become less optimal and can affect the overall stability of the cooperative. The purpose of this study is to ascertain how the Cooperative Rimbawan Sejahtera Bersama's financial statements are prepared [3]. Financial ratio analysis is a data analysis technique that uses indicators to evaluate the cooperative's financial performance [4].

Koperasi Bersama, as one of the economic institutions serving the needs of its members, also requires a system that can assist in the financial analysis process more quickly, accurately, and systematically. Cooperative managers are not only required to record financial transactions but also must be able to understand the meaning of the financial data to determine the right steps in managing the organization. In this context, the need for information technology becomes increasingly important, especially technology that not only presents data but also mimics the way an expert thinks in assessing the financial condition of the cooperative.

One form of technology application relevant to addressing this need is an expert system. An expert system is a computer-based system designed to adopt the knowledge and reasoning patterns of an expert into a program, so it can be used to assist users in solving specific problems. In the field of finance, expert systems can be utilised to analyse various financial indicators, identify problem symptoms, and provide conclusions and recommendations based on established rules. The advantage of expert systems lies in their ability to maintain the consistency of analysis, accelerate the assessment process, and reduce full dependence on the direct presence of experts. The data analysis method is financial ratio analysis, namely: liquidity ratio, solvency ratio, return on equity, and return on assets [5].

However, in the process of financial analysis, conditions of uncertainty often arise. Not all financial indicators directly indicate an absolute condition, because a symptom can point to more than one possible problem. For example, a decrease in cash can be caused by high operational expenses, low accounts receivable turnover, or ineffective financing management. In situations like this, a method that can accommodate the level of confidence in a decision is needed. The Certainty Factor method is one of the appropriate approaches because it can represent the level of certainty of an expert regarding the relationship between symptoms and conclusions. With this method, the system not only provides analysis results but also shows the level of confidence in those results.

The use of the Certainty Factor method in the financial analysis expert system for cooperatives is important because it can help managers understand the financial condition based

on a certain level of certainty. This method allows the analysis process to be conducted in a more rational and measurable way, especially when the available data does not yet fully provide a definitive conclusion. By combining expert knowledge and confidence level calculations, the system being developed is expected to provide analysis results that closely resemble the thinking of a cooperative financial expert. This adds value to cooperatives in improving the quality of decision-making. Certainty Factor (CF) Method. The CF method is a method used to indicate confidence in an event in the form of a fact or hypothesis based on evidence or expertise. Results [6]. Certainty Factor is a method that defines the degree of certainty regarding facts or rules to describe an expert's confidence in the problem at hand. In order to diagnose stomach disease, a website-based expert system was developed. [7], [8].

This Certainty Factor-based expert system may provide analytical results in line with the observations tested on farmers and experts, and it can function as intended with a 100% success rate [9]. Decision Support System (DSS) that employs popular techniques including SAW, AHP, and TOPSIS in addition to the MOORA and MOORSA approaches. A1 applicants receive the highest score of 0.651819 from the MOORA approach, which is renowned for its accuracy in handling several criteria[10].

Moreover, research on expert systems has mostly been applied in the fields of health, education, and device malfunction diagnosis, while their application in cooperative financial analysis is still relatively limited. However, cooperatives as people's economic institutions have a great need for intelligent systems that can assist in the sustainable evaluation of financial conditions. The limitations of studies in this field indicate a significant opportunity for further research development. Thus, this research not only has practical value for Koperasi Bersama but also contributes academically to the development of cooperatives.

Literature Review 2.1 Decision Support System (DSS)

Decision Support System (DSS) is designed to support all stages of decision-making, from identifying problems, selecting relevant data, determining the approach used in the decisionmaking process, to evaluating alternative selections. The Decision Support System (DSS) is a system intended to support semi-structured decision-makers. The Decision Support System (DSS) is intended to be a tool for decision-makers to expand their capacity, but not to replace judgement. [11].

The decision support process begins with the Intelligence phase, where reality is tested and problems are identified. Then comes the design phase, which is a model that describes how the system is built. This phase makes simple assumptions based on established rules and criteria, integrating all variables. Next, the model is validated and criteria are gathered for an evaluation of the identified options. Following this is the selection phase, which involves a solution objective within the model. The final phase is the implementation phase, where the success level of the system in solving the existing problem will be assessed. [12].

Decision Support System (DSS) is a system intended for managerial use to support semistructured decision-making. Herbert A. Simon defines decision-making in three stages: Intelligence, Design Choice, Implementation. According to a Decision Support System (DSS) can be defined as an information system that helps identify decision-making opportunities or provides information to assist in decision-making. With various special characteristics as mentioned above, decision support systems can provide benefits or utility for their users. The benefits obtained are as follows:

1. Capable of supporting the search for solutions to complex problems.
2. Quick response to unexpected situations in changing conditions.
3. Able to apply various different strategies to different configurations quickly and accurately.
4. New perspectives and lessons.
5. Facilitating communication.
6. Improving management control and performance. 7. Cost savings.

DSS provides support for primary decision-makers in semi-structured and unstructured situations by combining human judgement and computerised information. Various problems that cannot be solved (or satisfactorily solved) by other computerised systems, such as Electronic Data Processing or Management Information Systems, cannot be addressed by standard quantitative methods or tools either.

2.2 Certainty Factor

Certainty Factor is a method presented by Shortliffe and Buchanan, introduced during the development of MYCIN in 1975 to address issues related to an expert's uncertainty. The results of the Certainty Factor method calculations are used to solve problems with uncertain answers. The value of the certainty factor can be obtained in two ways, namely through the Net Belief method and interviews with experts. Here is an explanation of how to obtain the Certainty Factor value.

1. Net Belief

   Method The Net Belief Method is a method introduced by E. H. Shortliffe and B. G. Buchanan, where the certainty factor value is obtained from the calculation of the measure of belief and the measure of disbelief based on the probability of the hypothesis and evidence. Here is the formula for the Net Belief method.

$$CF(Rule) = MB\,(H, E) - MD\,(H, E)$$

$$MB\,(H, E) = \begin{cases} \dfrac{max\,[P(H|E),\ P(H)]}{max\,[1, 0] - P(H)} & P(H) = 1 \\ \dfrac{P(H) - P(H)}{1 - P(H)} & P(H) = 0 \end{cases}$$

$$MD\,(H, E) = \begin{cases} \dfrac{min\,[P(H|E),\ P(H) - P(H)]}{min\,[1, 0] - P(H)} & P(H) = 0 \\ \dfrac{P(H) - P(H)}{1 - P(H)} & P(H) = 1 \end{cases}$$

Explanation:

CF(Rule): Certainty factor.

MB (H, E): Measure of Belief towards hypothesis H, given evidence E with a value between 0 and 1.

MD (H, E): Measure of Disbelief towards evidence H, given evidence E with a value between 0 and 1.

P(H): Probability of the truth of hypothesis H.

P(H—E): Probability that H is true because of fact E.

2. Interview with Experts

   In the expert interview method, the Certainty Factor value can be obtained from conclusions based on the expert's criteria. Here are the cf values based on terms from the certainty value table.

Table 1. CF Value Table Based on Term

Term	Certainty Factor
Definitely not	-1.0
Almost certainly not	-0.8
Probably not	-0.6
Maybe not	-0.4
Unknown	-0.2 to +0.2
Maybe	+0.4

Probably	+0.6
Almost certainly	+0.8
Definitely	+1.0

For the calculation of the Certainty Factor value, there are 3 methods. In the first calculation formula, if the evidence and hypothesis known are only 1 or singular, then the formula can be used:

$$CF(H|E) = CF(E) \times CF(H)$$

In the second calculation formula, if the known evidence is more than one, and the hypothesis is single, then the formula can be used:

1. On rules AND

$$CF\,(H, E) = min\,[CF(E_1), CF(E_2), \ldots, CF(E_n)] \times CF\,(rule)$$

2. On rules OR

$$CF\,(H, E) = max\,[CF(E_1), CF(E_2), \ldots, CF(E_n)] \times CF\,(rule)$$

In the third calculation formula, the combination formula is used from two rules with different evidence but resulting in the same hypothesis. The combination formula is divided into three methods, namely, if the values of CF1 and CF2 are greater than zero, the combination Certainty Factor formula can be written as follows.

$$CF\,(CF_1, CF_2) = CF_1 + CF_2(1 - CF_1)$$

If the value of CF1 or CF2 is less than zero, then the Certainty Factor formula can be written as follows.

$$CF\,(CF_1, CF_2) = \frac{CF_1 + CF_2}{1 - min[CF\,, CF\,]}$$

If the values of both CF are less than zero, then the Certainty Factor formula can be written as follows.

$$CF\,(CF_1, CF_2) = CF_1 + CF_2(1 + CF_1)$$

Explanation:
CF (CF1, CF2): The Certainty Factor value is a combination of the CF values of the two symptoms
CF1: The CF value of the first symptom.
CF2: The CF value of the second symptom.

Research Methodology

This research aims to implement a financial analyst expert system at Koperasi Bersama using the Certainty Factor method. The approach used in this study is experimental with a system research design, where the expert system will be built and tested using the cooperative's historical financial data. This system is designed to assist cooperative managers in analysing financial conditions more quickly, accurately, and systematically, while also reducing reliance on manual analysis, which is often prone to errors and subjectivity. The research process begins with problem identification, the collection of primary and secondary data through interviews with financial experts and the analysis of cooperative financial reports. Next, the design and

development of the expert system were carried out, followed by the implementation and testing of the system using relevant financial data.

The Certainty Factor method is used to address uncertainty in financial decision-making by measuring the level of confidence in each analysis conducted. After implementation, the system is tested to evaluate its accuracy and effectiveness in providing appropriate recommendations based on the existing financial data. Testing was conducted by comparing the results of the expert system analysis with the manual analysis performed by an expert. The results of this research are expected to make an important contribution to Koperasi Bersama in improving financial management and data-driven decision-making, as well as enriching research on the application of expert systems in the field of cooperative financial management.

Results

The Certainty Factor method is a method used to resolve cases of uncertainty, where its measure is based on a fact or rule. The Certainty Factor is a numerical value of evidence accepted as a conclusion. Expert systems reason about the information in the knowledge base and in the workplace, and to formulate conclusions. Generally, there are two approaches used in the inference mechanism for rule testing, namely the certainty factor. The financial analysis expert system at Koperasi Bersama is designed to provide analytical facilities for the company's finances.

Here is the data on the problem, the cause of the problem, as well as the MB value and MD value for each cause:

1. Uncollectable receivablesCauses:
   a. Delivery of goods does not match the invoice
   b. Outlet bankrupt Solutions:
   1. Resend the delivery if proven to be more or miscalculated
   2. Submit a write-off for the outlet
2. Discrepancy between cash sales receipts and deposits Causes:
   a. Delay in inputting sales funds
   b. Discrepancy with the responsible admin Solutions:
   1. Deposit the discrepancy and perform activities on time
   2. Immediately issue a warning letter to the responsible admin
3. NKA (National Key Account) receivables are taking too long to be paid Causes:
   a. Invoice exchanges are taking too long from the issuance of the invoice
   b. Discrepancies between the tax invoice amount issued by the supplier and the Purchase Order (PO) can result in the invoice not being paid Solutions:
   1. Monitor invoice exchanges and the matching process in the system.
   2. Admin ensures the PO price matches the price applicable at the distributor 4.

Shortage of daily operational funds Causes:
   a. Operational funds in the form of petty cash are used for non-operational expenses
   b. Reimbursement of funds from the Head Office (HO) takes too long Solutions:
   1. Before funds are needed, the expenses to be paid must be submitted in advance
   2. Follow up with the finance department at the Head Office to ensure funds are transferred promptly and make sure all claim documents are in accordance with procedures to avoid rejection

5. Expired claim receivables Causes:
   a. Delay in submitting claims to the outlet
   b. Incomplete documents from the area for submitting claims to the outlet Solutions:
   1. The area must set a deadline to expedite the claims process 2.

Complete the documents for outlet claims according to procedure 6.

Value-added tax (VAT) cannot be credited Causes:

a. Return notes are not issued by all outlets collaborating with Koperasi Bersama
b. Return notes are issued by non-VAT registered outlets
c. VAT registered outlets do not issue return notes Solution:

1. Ensure that all outlets transacting with Koperasi Bersama are VAT registered so that return notes can be credited
2. Request the VAT return to be billed again so it can be deducted without VAT
3. Ensure return notes are reissued

Table 2. Cause Data in the Cooperative

No	Code Cause	Cause
1	P001	The delivery of the goods does not match the invoice.
2	P002	Bankrupt Outlet
3	P003	Pending input of sales funds
4	P004	There is a deviation with the on-duty admin.
5	P005	The invoice exchange is taking too long since the issuance of the receipt.
6	P006	Discrepancies between the nominal value of the tax invoice issued by the supplier and the Purchase Order (PO) can result in the invoice not being paid.
7	P007	Operational funds in the form of petty cash are used for expenses outside of daily operations.
8	P008	The reimbursement from the Head Office (HO) is taking too long.
9	P009	The claim submission to the outlet is taking too long.
10	P0010	The documents from the area are incomplete for the claim submission to the outlet.
11	P0011	The creation of return notes is not done by all outlets that collaborate with Koperasi Bersama.
12	P0012	Return notes are issued by outlets that are not Taxable Entrepreneurs (PKP).
13	P0013	PKP outlets that do not issue return notes
14	P0014	The check was received by the bank after the due date, causing a delay in its clearance.
15	P0015	Admin forgot to do the bank clearing.
16	P0016	Empty checks and several times found outlets with incorrect check date entries.
17	P0017	Credit notes are not issued daily by the logistics department.
18	P0018	The admin took too long to input the Credit Note into the system.
19	P0019	The closing process is not current.
20	P0020	Lack of diligence in calculating and summing the funds received in the cash register.
21	P0021	Sales did not update the prices to consumers for MTI and

		NKA
22	P0022	Paying short-term debt interest
23	P0023	Not monitoring the petty cash expenditures and income
24	P0024	There was a loss of the payment receipt/invoice.

Table 3. Problem Data at Koperasi Bersama with MB and MD Values

No	Problem Code	Problem Data	Code Cause	MB	MD
1	M001	Uncollectable receivables	P001	0.8	0.2
			P002	0.6	0.5
2	M002	The difference between receipts and sales deposits is not the same.	P003	0.9	0.1
			P004	0.7	0.3
3	M003	NKA (National Key Account) receivables are taking too long to be paid.	P005	0.8	0.2
			P006	0.6	0.4
4	M004	Shortage of daily operational funds	P007	0.8	0.2
			P008	0.7	0.3
5	M005	Piutang Claim expired	P009	0.8	0.2
			P0010	0.6	0.4
6	M006	Value Added Tax (VAT) cannot be credited	P0011	0.8	0.2
			P0012	0.5	0.5
			P0013	0.5	0.5
7	M007	Problematic giro clearing	P0014	0.6	0.4
			P0015	0.5	0.5
			P0016	0.6	0.4
8	M008	Accumulated Credit Notes	P017	0.7	0.3
			P018	0.7	0.3
9	M009	The large cash difference deposited into the bank	P0019	0.7	0.3
			P0020	0.8	0.2
10	M0010	POs are often not recorded according to their POs due to discrepancies.	P0021	0.8	0.2
			P0022	0.6	0.4
11	M0011		P0023	0.8	0.2

		Difference in petty cash finances	P0024	0.7	0.3

Process needs analysis, where the cause data selected by experts will be processed using the Certainty Factor. The calculation method involves determining the MB value and its MB value for the previously selected cause data to find the CF value from several financial issues experienced. For example, a manual calculation case for input needs analysis includes the cause data for financial issues at Koperasi Bersama experiencing:

Example 1:

The delivery of goods does not match the invoice with a value of MB=0.8 and MD=0.2, then the Outlet goes bankrupt with MB=0.6 and MD=0.5.

So the CF calculation is:

MB = MB (h, e1) + MB (h, e2) * (1-MB [h, e1])
= 0.8 + 0.6*(1-0.8)
= 0.92

MD = MD (h, e1) + MD (h, e2) * (1-MD [h, e1])
= 0.2 + 0.5*(1-0.2)
= 0.6

CF[h,e] = MB[h,e]-MD[h,e]
= 0.92-0.6
= 0.32 Conclusion:

The finances are experiencing issues with uncollectable receivables with a CF value of 0.32.

Example 2:

Cooling down the sales fund input with an MB value of 0.9 and an MD value of 0.1, then there is a deviation with the admin on duty with an MB value of 0.7 and an MD value of 0.3.

Therefore, the CF calculation is:

MB = MB (h, e1) + MB (h, e2) * (1-MB [h, e1])
= 0.9 + 0.7*(1-0.9)
= 0.97

MD = MD (h, e1) + MD (h, e2) * (1-MD [h, e1])
= 0.1 + 0.3*(1-0.1)
= 0.37

CF[h,e] = MB[h,e]-MD[h,e]
= 0.97-0.37
= 0.6

Conclusion:

The finance department is experiencing issues with the discrepancy between sales receipts and deposits, resulting in a CF value of 0.6.

Example 3:

The invoice note is too delayed compared to the book note, with an MB value of 0.8 and an MD value of 0.2. Additionally, there is a discrepancy between the tax invoice issued by the supplier and the purchase order (PO), which could lead to the invoice not being paid, with an MB value of 0.6 and an MD value of 0.4. Therefore, the CF calculation is:

MB = MB (h, e1) + MB (h, e2) * (1-MB [h, e1])
= 0.8 + 0.6*(1-0.8)
= 0.92

MD = MD (h, e1) + MD (h, e2) * (1-MD [h, e1])
= 0.2 +0.4*(1-0.2)

= 0.52

CF[h,e] = MB[h,e]-MD[h,e]
= 0.92-0.52
= 0.4

Conclusion:

The finance department is experiencing issues with NKA (National Key Account) receivables being paid too late with a CF value of 0.4.

Example 4:

Operational funds in the form of petty cash are used for expenses outside daily operations with an MB value of 0.8 and an MD value of 0.2, followed by fund replacements from the Head Office (HO) taking too long with an MB value of 0.7 and an MD value of 0.3.

Therefore, the CF calculation is:

MB = MB (h, e1) + MB (h, e2) * (1-MB [h, e1])
= 0.8 + 0.7*(1-0.8)
= 0.94

MD = MD (h, e1) + MD (h, e2) * (1-MD [h, e1])
= 0.2 +0.3*(1-0.2)
= 0.44

CF[h,e] = MB[h,e]-MD[h,e]
= 0.94-0.44
= 0.5

Conclusion: The finances are experiencing a problem with a daily operational fund shortage with a CF value of 0.06. Example 5:

Delayed claim submission to the outlet with an MB value of 0.8 and an MD value of 0.2, then the documents from the area are incomplete for the claim submission to the outlet with an MB value of 0.6 and an MD value of 0.4.

So the CF calculation is:

MB = MB (h, e1) + MB (h, e2) * (1-MB [h, e1])
= 0.8 + 0.6*(1-0.8)
= 0.92

MD = MD (h, e1) + MD (h, e2) * (1-MD [h, e1])
= 0.2 +0.4*(1-0.2)
= 0.52

CF[h,e] = MB[h,e]-MD[h,e]
= 0.92-0.54
= 0.38

Conclusion:

The finances are experiencing an issue with expired receivable claims with a CF value of 0.38.

Conclusion

Based on the research results regarding the implementation of a financial analyst expert system at Koperasi Bersama using the Certainty Factor method, it can be concluded that this system is capable of making a significant contribution to improving the efficiency and accuracy of the cooperative's financial analysis. The developed expert system is able to address the uncertainties that often arise in financial analysis by measuring the level of confidence in the analysis results using the certainty factor. The use of the Certainty Factor in this system allows the cooperative management to obtain more measurable and consistent recommendations, thereby minimising subjectivity in decision-making.

System testing shows that the analysis results provided by the expert system are overall consistent with the manual analysis conducted by financial experts, with a calculable level of

certainty. Thus, this expert system is expected to become an effective tool in cooperative financial management, assisting managers in making more accurate and data-driven decisions. This research also contributes to the development of expert system applications in the field of financial management, particularly in the cooperative sector, and opens up opportunities for further research related to the application of smart technology in the management of community-based economic organisations.

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