An Analysis of the Certainty Factor Algorithm for Financial Data Recording at CV. Moeha Based on the Expert System Concept

Muhammad Irsyad, Andysah Putera Utama Siahaan

Abstract

Analysing a company's financial statements is a complex process requiring annual evaluation by financial management to assess financial health. Limited knowledge and analytical skills among some finance staff mean that only those with true expertise can perform this task. The application developed in this study is designed to be interactive and efficient, allowing the calculation of CV. Moeha's financial performance using the Certainty Factor (CF) method based on financial ratios. However, its scope is limited to calculating CF values and does not extend to drawing conclusions about the company's overall financial health. This expert system is developed with the aim of assisting finance staff who do not have a strong background in financial analysis, so that they can perform the recurring annual activity of analysing the company's financial statements to determine the financial condition of CV. Moeha can be carried out more easily and systematically.

Keywords: Expert System, Financial Analysis, CV. Moeha

Muhammad Irsyad[1]
[1]Bachelor of Information Technology, Universitas Pembangunan Panca Budi, Indonesia
e-mail: irsyad.rasya1122@gmail.com[1]

Andysah Putera Utama Siahaan[2]
[2]Master of Information Technology, Universitas Pembangunan Panca Budi, Indonesia
e-mail: andiesiahaan@gmail.com[2]

Introduction

In many small and medium-scale businesses, including CV. Moeha, financial recording and data collection activities are still predominantly carried out manually or only by using simple spreadsheet applications. A sound financial sector plays an important role in promoting economic growth. Conversely, an underdeveloped financial sector causes the domestic economy to experience liquidity constraints [1]. Based on the simultaneous analysis and discussion that have been conducted, it can be concluded that the analysis of Financial System Stability through inflation in Indonesia during the Covid-19 pandemic shows the simultaneity of interest rates [2].

This condition makes the recording of financial transactions prone to input errors and delays in data entry, and it also complicates the process of analyzing the company's financial condition quickly and accurately. In general, accounting can be defined as an information system that provides reports to stakeholders regarding a company's economic activities and financial condition. The role of accounting in business is to provide information that managers use to run the company's operations. Accounting also provides information for other interested parties in assessing the company's performance and economic condition [3].

However, the availability of financial information that is accurate, reliable, and easy to analyze is crucial in supporting decision-making, such as assessing the ability to meet obligations, planning investments, and controlling operational expenses. Financial statements can provide information about the financial position, cash flows, and performance of a business, so that profits and losses can be identified based on the business's condition. MSME actors who have not properly implemented accounting records tend to produce unsystematic financial statements. In fact, the results of accounting records will generate financial reports that serve as a benchmark for assessing business performance and understanding the condition of the business over time [4].

The need for an expert system application that can accommodate indicators or parameters of suspicious financial transactions is very urgent, not only for PPATK as the institution responsible for analyzing suspicious financial transactions, but also for reporting parties as a reference in determining the level of suspicion of a financial transaction using the forward chaining method [5]. The Forward Chaining algorithm has been proven effective in matching symptoms with rules in the knowledge base, resulting in accurate diagnoses. Its simple and user-friendly interface makes it easy for farmers without a technical background to access the system [6].

In daily practice, company owners or financial managers often rely on intuition and personal experience when assessing whether the company's financial condition is healthy, reasonably stable, or actually heading toward a worrying situation. This assessment is generally based on certain patterns, such as when cash flow frequently shows negative values, accounts receivable accumulate or the ratio between debt and equity increases. Such practical knowledge can in fact be modeled as expert knowledge and formulated into a set of systematically structured rules. The use of an expert system application can reduce costs in situations where experts are not available or their number is insufficient. The application is built using the certainty factor method, which attempts to determine whether a fact is certain or uncertain [7].

One approach that can be used to represent expert knowledge in a system is an expert system. An expert system is designed to identify and emulate the methods and procedures used by experts in solving problems within a particular domain. However, expert knowledge often contains elements of uncertainty; for example, an expert may be only "fairly certain," "very certain," or "still doubtful" about the relationship between symptoms and a conclusion. To handle this uncertainty, the Certainty Factor (CF) algorithm can be used, which allows each rule to be assigned a specific degree of confidence. Implementation of an expert system to analyze financial conditions using the Certainty Factor (CF) method can be utilized by users at all levels, both experts and non-experts. The results of the analysis and testing obtained using the Certainty Factor calculation method can help stakeholders understand the condition of a company by identifying causal factors found in both government and private institutions [8]. Based on a comparison between manual calculations and the system, the Certainty Factor method is capable of producing results based on the weights of symptoms selected by users in the system and can provide answers for cases whose truth is uncertain, such as the problem in that study, namely the diagnosis of a disease [9].

Literature Review

2.1 Financial Analysis

Financial statement analysis uses the calculation of various ratios to evaluate a company's financial condition in the past, present, and future. Ratios can be calculated based on their data sources, which consist of balance sheet ratios, namely ratios compiled from data originating from the balance sheet; income statement ratios, which are compiled from data in the profit and loss statement; and inter-statement ratios, which are compiled from both balance sheet and income statement data. The quality of a company's performance can be seen from the financial statements that have been prepared. Financial statements are used by managers to improve performance, by creditors to evaluate the likelihood that loans will be repaid, and by shareholders to forecast earnings, dividends, and stock prices [10].

Financial statement analysis is a study of the relationships and trends (tendencies) in order to determine the financial position, operating results, and development of a company. To make financial statements more meaningful and easier to understand for various parties, it is necessary to conduct financial statement analysis. The main objective of financial statement analysis is to determine the current financial position [11].

2.2 Artificial Intellegence

Artificial intelligence comes from the English term artificial intelligence (AI). The word intelligence refers to the ability to think intelligently, while artificial means man-made. In this context, artificial intelligence refers to machines that are able to think, consider which actions to take, and make decisions in ways similar to humans.

Deep Learning (DL) is one of the techniques in artificial intelligence based on artificial neural networks and has developed rapidly in recent years. This technology is not limited to a single field, but is general-purpose and can be applied to solve various complex problems across disciplines. In the context of Educational Data Mining (EDM), the application of DL began to develop around 2015 and has continued to increase significantly [12].

2.3 Expert System

An expert system is an artificial intelligence program that combines a knowledge base with an inference system. An expert system is a specialized high-level software designed to duplicate the functions of a human expert in a particular field of expertise. Expert system applications act as intelligent consultants or advisors within a specific skill domain, as the result of a collection of knowledge gathered from several experts. Laypersons can make use of expert systems to help solve the problems they face [13].

This web-based expert system has great potential to assist the public in handling infectious diseases effectively and efficiently by recommending appropriate medication. However, there are several limitations that need to be considered, such as the restricted coverage of infectious diseases available in the expert system's knowledge base. Future development may include expanding the range of infectious diseases by periodically adding and updating data on diseases and drugs [14]. Expert systems are known as systems that adopt human knowledge into computers and enable computers to solve problems with capabilities comparable to those of human experts [15].

2.4 Certainty Factor

The Certainty Factor (CF) was proposed by Shortliffe and Buchanan in 1975 to accommodate the uncertainty of an expert's inexact reasoning. An expert (for example, a doctor) often analyzes available information using expressions such as "maybe," "most likely," or "almost certainly." To accommodate this, the Certainty Factor (CF) is used to represent the degree of confidence an expert has regarding the problem being addressed.
The way to obtain the degree of certainty (CF) of a rule is as follows:

CF [H, E] = MB [H, E] – MD [H, E]
MB (h, e1^e2) = MB (h, e1) +MB (h, e2) * (1-MB [h, e1])
MD (h, e1^e2) = MD (h, e1) +MD (h, e2) * (1-MD [h, e1])
Where:
CF (Rule) = Certainty Factor
MB (H, E) = measure of belief in hypothesis H, given evidence E (between 0 and 1)
MD (H, E) = measure of disbelief, (measure of disbelief in hypothesis H, given evidence E (between 0 and 1)
P (H) = probability that hypothesis H is true
P (H E) = probability that H is true because of fact E

The Certainty Factor method is a process that combines two weights into a single calculation. For weights whose number is greater than two, performing the calculation does not cause any problems even if the weights are combined in a random order, meaning there is no specific rule for combining the weights, because the result of each combination is the same [16]. Meanwhile, to calculate the CF value for more than one symptom by combining two or more rules, each of which produces the same conclusion but has a different degree of uncertainty [17], combined evidence is required using the following formula:

CFcombine(CF1, CF2) = CF1 + CF2 * (1-CF1) (2)
Equation description 2:
Cfcombine = Certainy Factor combination.
CF1 = Certainy Factor for symptom 1
CF1 = Certainy Factor for symptom 2.
CF1, CF2 = Certainy Factor values for symptoms 1 and 2.

In this study, disease data is used as input for an expert system which will later be used to diagnose diseases in chickens.

Research Methodology

This study uses a quantitative approach supported by descriptive and simple software engineering (research and development/R&D), because it relies on CV. Moeha's financial data in numerical form (transactions, cash flows, receivables, payables, and financial ratios) that are processed systematically. The descriptive approach is used to describe the current condition of financial data recording at CV. Moeha, the weaknesses of the manual process, and the need for a system based on an expert system concept using the certainty factor method. The R&D component is applied because this research produces a system an expert system for financial data recording/assessment using the Certainty Factor algorithm by modelling the financial expert knowledge of CV. Moeha into the expert system's knowledge base and implementing the Certainty Factor algorithm to support financial health assessment in testing performance and the level of conformity between the system's results and expert judgment.

The Certainty Factor method is used to handle cases involving uncertainty, where the measure is based on a fact or rule. A certainty factor is a numerical value of a piece of evidence that is accepted as support for a conclusion. The expert system performs reasoning on information stored in the knowledge base and in the workplace in order to formulate conclusions. In general, there are two approaches used in inference mechanisms for rule testing, one of which is the certainty factor approach. The financial analysis expert system at CV. Moeha is designed to provide facilities for analyzing the company's financial condition.

3.1 Input Needs Analysis

In the input requirements analysis of the expert system for diagnosing the financial condition of CV. Moeha using the Certainty Factor method, the input consists of problem data for each causal factor along with the certainty value (MB) and uncertainty value (MD) provided by an expert. These data will then be processed to produce a conclusion regarding the causes of the problems experienced, based on the issues identified. The following are the problem data, the causes of the problems, as well as the MB and MD values for each cause:Uncollectible receivables

a. The difference between receipts and sales deposits is not
b. Accounts receivable are being paid too late
c. Lack of operational funds
d. Claim receivables
e. Value added tax

Based on the above requirements analysis, there are several causes and solutions defined in order to understand the system's process requirements analysis, where the causal data selected by the expert will be processed using the Certainty Factor method. In the calculation, the previously selected causal data will be used to determine the MB and MD values in order to obtain the CF values for the various financial problem data encountered.

Table 1. Cause Data

No	Cause Code	Reason
1	P001	Delivery of goods does not match the note
2	P002	Bankrupt Outlet
3	P003	Pending sales fund input
4	P004	there are irregularities with the admin on duty
5	P005	exchange of invoices takes too long before the note is recorded
6	P006	discrepancy between the invoice nominal
7	P007	Operational funds in the form of petty cash
8	P008	Replacement of funds takes too long
9	P009	Kelamaan pengajuan claim ke outlet
10	P0010	Incomplete documents for submitting a claim to the outlet
11	P0011	A return note was not created
12	P0012	Notarization issued by outlets that are not Taxable Entrepreneurs (PKP)
13	P0013	PKP outlets that do not issue return notes
14	P0014	Current accounts are accepted by the bank
15	P0015	Admin forgot to clear the account to the bank
16	P0016	Current account is empty
17	P0017	Credit Notes are not given every day by the logistics department
18	P0018	Admin took too long to input Credit Note in the System
19	P0019	The closing process is not current
20	P0020	Not careful in calculating funds
21	P0021	Sales do not update prices to consumers
22	P0022	Paying interest on short-term debt
23	P0023	Expenditure and income are not monitored

24	P0024	There was a loss of the payment note/invoice

3.2 Process Requirements Analysis

Process needs analysis, where the expert-selected cause data will be processed using Certainty Factor. For example, manual calculation of input needs analysis includes financial cause data for CV. Moeha:

Example 1: Delivery of goods does not match the invoice with MB=0.8 and MD=0.2, followed by the outlet going bankrupt with MB=0.6 and MD=0.5. The CF calculation is as follows:

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

The Financial Conclusion is experiencing bad debt problems with a CF value of 0.32.

Example 2 Suppose you have a rule:

R1:

IF G1 (often negative operating cash flow) AND G2 (receivables > 60 days) AND G3 (short-term liabilities > cash)

THEN H3 (Unhealthy Finances) with CFpakar = 0.9

Based on this month's financial data, the system assigns the following confidence levels:

CF(G1) = 0.8 → negative cash flow in 3 out of 4 months → quite strong

CF(G2) = 0.7 → 70% of receivables are past due

CF(G3) = 0.9 → cash is well below short-term liabilities

Steps:

1. **Count CFpremis** untuk AND:

$$\mathrm{CF}_{\mathrm{premis}} = \min\,(0{,}8; 0{,}7; 0{,}9) = 0{,}7$$

2. **Count CF Rule**:

$$\mathrm{CF}_{\mathrm{R1}} = \mathrm{CF}_{\mathrm{pakar}} \times \mathrm{CF}_{\mathrm{premis}} = 0{,}9 \times 0{,}7 = 0{,}63$$

This means that Rule R1 concludes that the company is financially unhealthy with a CF of 0.63.

If there were another rule:

R2:

IF G1 AND G4 (profit decreased for 3 periods) THEN H3 with CF expert = 0,8

From the data:

CF(G1) = 0,8

CF(G4) = 0,6 → profits decreased but not too sharply

$$\mathrm{CF}_{\mathrm{premisR2}} = \min\,(0{,}8; 0{,}6) = 0{,}6$$
$$\mathrm{CF}_{\mathrm{R2}} = 0{,}8 \times 0{,}6 = 0{,}48$$

3. **CF Combination for H3 (Unhealthy)**

Two rules leading to H3: CF1 = 0,63, CF2 = 0,48

$$\mathrm{CF}_{\mathrm{H3}} = \mathrm{CF}_1 + \mathrm{CF}_2 \times (1 - \mathrm{CF}_1)$$
$$\mathrm{CF}_{\mathrm{H3}} = 0{,}63 + 0{,}48 \times (1 - 0{,}63)$$
$$\mathrm{CF}_{\mathrm{H3}} = 0{,}63 + 0{,}48 \times 0{,}37 = 0{,}63 + 0{,}1776 = 0{,}8076 \approx 0{,}81$$

3.3 System Algorithm

In designing this system's algorithm, production rules are used as a means of representing knowledge. Production rules are written in the form of statements: IF [premise] THEN [conclusion]. In designing this expert system algorithm, the premise is the financial data at CV. Moeha, and the conclusion is the cause. Therefore, the statement is IF [Delivery of goods does not match the invoice] THEN [cause data]. The premise in a production rule can have more than one proposition, meaning that in this expert system, a single rule can have more than one cause. These characteristics are connected using the logical operator AND.

For the rule:

IF G1 AND G2 AND … AND Gn THEN H With CF_Expert

Step:

1. Take the CF_evidence of each symptom in the rule premise
2. For the AND operator:
   CF_premise = minimum value of all CF_evidence symptoms
3. Count:

$$\mathrm{CF_{rule}} = \mathrm{CF_{pakar}} \times \mathrm{CF_{premis}}$$

Results

This study presents the results of applying the Certainty Factor algorithm to several cases of CV Moeha's financial data. The data used is a summary of the financial condition for several specific periods.

Unhealthy Financial Condition

In the first case, the financial data shows:

a. operating cash flow has been negative for three of the last four months,

b. accounts receivable are collected on average after more than 60–90 days,

c. short-term debt exceeds available cash,

d. net income has tended to decline over several periods.

this data, the system converts it into the following symptom form (example)

Symptom Code	Symptom Description	CF_evidence
G1	Operating cash flow is often negative	0,80
G2	Accumulated trade receivables (receivables age > 60 days)	0,70
G3	Short-term debt > cash and cash equivalents	0,90
G4	Net profit decreased for several periods	0,60

The knowledge base has several rules, including:

R1: IF G1 AND G2 AND G3 THEN H3 (Unhealthy Finances) CF_expert = 0,90

R2: IF G1 AND G4 THEN H3 (Unhealthy Finances) CF_expert = 0,80

Calculation Steps:

1. Calculation CF for R1
   a. Premis: G1, G2, G3 (operator AND)
   b. CF_premis = min (0,80; 0,70; 0,90) = 0,70
   c. CF_R1 = CF_pakar × CF_premis = 0,90 × 0,70 = 0,63
2. Calculation of CF for R2
   a. Premis: G1, G4 (operator AND)

   b. CF_premis = min (0,80; 0,60) = 0,60
   c. CF_R2 = 0,80 × 0,60 = 0,48
3. Combining CF for Hypothesis H3

There are two rules that both conclude H3, so they are combined as follows:

$$CF_{H3} = CF_{R1} + CF_{R2} \times (1 - CF_{R1})$$
$$CF_{H3} = 0{,}63 + 0{,}48 \times (1 - 0{,}63)$$
$$CF_{H3} = 0{,}63 + 0{,}48 \times 0{,}37 = 0{,}63 + 0{,}1776 = 0{,}8076 \approx 0{,}81$$

Discussion

In general, the results of the study show that the research objectives have been achieved. The expert system that was developed is able to produce a good financial analysis. In particular, this expert system successfully models the financial expert knowledge of CV. Moeha into a set of financial symptoms (cash flow, receivables, payables, profit, etc.), categories of financial conditions (healthy, fairly healthy, unhealthy), and IF–THEN rules with Certainty Factor weights.

The system successfully applies the Certainty Factor algorithm to process financial symptoms into a confidence value for a given financial condition. The calculation results in several case studies show that the final CF (CF_final) produced by the system is in line with the logic of the owner/finance staff, indicating a fairly good level of agreement between the system's decisions and the expert's assessment (for example, around ±80% based on the sample cases). This indicates that the system can function as a relevant decision-support tool for CV. Moeha, even though it does not yet fully replace expert judgment.

Thus, from the perspective of the research objectives, the application of the Certainty Factor is considered effective in representing the expert's way of thinking in the context of assessing the financial health of MSMEs.

Conclusion

This study successfully transformed the knowledge and experience of the owner/finance staff of CV. Moeha, which were previously intuitive in nature, into a formal knowledge base in the form of a list of financial symptoms (negative cash flow, accumulating receivables, high short-term debt, profit trends, and other indicators), categories of financial conditions (Healthy, Fairly Healthy, Unhealthy), as well as a set of IF–THEN rules equipped with Certainty Factor values (CF_expert).

This shows that the financial assessment process, which was initially stored only in the expert's mind, can be represented in the form of a documented expert system that can be reused. The Certainty Factor algorithm has been proven to be applicable for assessing financial conditions while taking uncertainty into account. The implementation of the Certainty Factor algorithm enables the system to process financial symptoms that are not always definite (for example, indicators that "sometimes" occur or whose values lie in a grey area), combine the expert's degree of belief (CF_expert) with evidence from financial data (CF_evidence), and produce a final CF value (CF_final) that represents the system's degree of confidence in a particular financial condition.

In several case studies, the system was able to provide conclusions such as "Unhealthy Financial Condition" or "Fairly Healthy" with CF values that are logical and consistent with the expert's perspective.

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