Expert Systems Are Used in the Analysis of PT.X Financial Budget. X Employing the Certainty Factor Approach

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Abstract

This research aims to analyse the financial expenditure budget at PT. X using the Certainty Factor (CF) method. In budget management, companies often face uncertainty in planning and allocating funds accurately, especially for costs that cannot be predicted precisely. The Certainty Factor method is used to provide better estimates by considering the level of certainty regarding various factors that influence budget decisions. This research uses historical budget data of PT. X for a specific period and applies the CF method to measure the extent to which uncertainty can be controlled in budget decision-making. The research results show that the CF method can provide a clearer picture of spending priorities that need to be funded and identify areas with high levels of uncertainty that require more attention. This research contributes to the development of more effective and efficient budgeting planning techniques, and provides recommendations for PT. X to improve the accuracy of future budget expenditures.

Keywords: *Financial Budget, Expenditure, Certainty Factor, Budget Planning, Uncertainty*

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Introduction

Through financial analysis, an overview of the company's financial health can be obtained, both currently and in the past, allowing for the identification of the company's strengths and weaknesses based on the analysed historical data. The information generated can then be used to make decisions regarding plans for company expansion, investment, sourcing operational funds, and more. However, in conducting financial analysis, several obstacles have been identified, including the lack of analysts and the financial employees' skills to analyse the company's finances. Therefore, an effort is needed to create experts who can handle this issue. As technology develops, it is capable of adopting human processes and ways of thinking, namely Artificial Intelligence technology. Strengthening technology infrastructure, increasing human resource capacity, changing curriculum, and creating laws that encourage the appropriate use of AI are all part of the deployment of AI. To achieve the best and longest-lasting results, the use of AI in higher education must be done gradually and adaptably while taking Indonesia's social, economic, and cultural context into account [1].

AI is currently in a new hype phase due to machine learning, a technology that helps computers learn from data. Making computers learn from data means not relying on human programmers to set operations (tasks), but rather deriving them directly from examples that show how the computer should behave. It's like teaching a baby how to behave through examples. Machine learning has a trap because computers can learn how to do things wrong through careless teaching. [2]. One of the rapidly developing branches of computer science today is artificial intelligence, which is created so that computer machines can perform tasks as well as and as good as humans. An expert system is one part of Artificial Intelligence that contains knowledge and experience inputted by many experts into a specific area of knowledge, allowing anyone to use it to solve various specific problems. That artificial intelligence technology, or does it really cause us to lose our ability to learn and become less clever than AI? The author reviewed the literature on the advantages, drawbacks, and prudent application of AI technology [3].

Financial budget planning is one of the important aspects of company management, especially in managing the allocation of funds for various operational and development needs. A well-prepared budget can serve as a tool to direct the company's activities to be more structured and efficient. However, in practice, budget planning often faces high uncertainty, both in fixed and variable cost aspects. This is caused by various factors that can influence budget decisions, such as price fluctuations, changes in market demand, and unpredictable economic conditions. Budget analysis is a strategic instrument for financial planning and management. This investigation demonstrates how budgets can assist businesses in creating methodical financial planning using a qualitative descriptive method and a literature study methodology [4]. Managers or business executives will find it simpler to carry out and oversee the planned work programs with the precise budget. An accurate and timely budget realisation report is necessary so that any negative deviations can be predicted early on and the budget generated reflects fairness and the implementers feel motivated rather than under pressure. [5].

In this context, PT. X, as one of the companies operating in the [mention industry] sector, faces challenges in budget management, particularly in planning the allocation of funds for various needs. The uncertainty arising from changes in the external and internal conditions of the company often makes budget planning suboptimal, even leading to waste or shortages in certain sectors. The Certainty Factor (CF) method is one of the approaches that can be used to address this uncertainty issue. The Certainty Factor is a method commonly used in expert systems to estimate the degree of certainty of a decision based on the available information. The goal of this research is to develop an expert system that can use the certainty factor technique to identify the degree of social media addiction [6]. **T**he technique is the Certainty Factor, a metric that is typically employed in expert systems to demonstrate whether a fact is certain or doubtful [7].

By applying this method, the company can evaluate various factors that influence the budget, such as cost estimates, inflation rates, and potential market fluctuations, and assign weights to each factor based on the level of certainty it possesses. In addition to providing answers to problems with unclear truth, like the problem in this research, which is the diagnosis of a sickness, the Certainty Factor approach can produce correct findings from computations based on the weights of symptoms selected by the user in the system. Solution resolves with uncertainty values using the Certainty Factor approach. *A technique known as the certainty factor is used to determine the confidence value* [8], [9], [10]. An accurate and efficient system is produced by applying the Certainty Factor approach. Experts tested the developed system's viability, and the results showed that it was 100% feasible, or "Highly Feasible." [1]. The certainty factory's benefit is that it may be used to quantify uncertainty, such as in a disease diagnosis [11].

The application of the Certainty Factor method in the financial budget analysis of PT. X is expected to provide a clearer and more objective picture of more efficient and targeted fund allocation. By using this method, the company can identify areas that require more attention and manage existing uncertainties, thereby making more informed decisions and reducing the risk of waste. Through this research, it is hoped that practical solutions can be found for more accurate and reliable budget planning, as well as contributing to the improvement of managerial effectiveness at PT. X in managing financial resources. This research also aims to enrich the existing literature on the use of the Certainty Factor method in the field of corporate financial budget planning, which has not been widely applied in Indonesia, particularly in the mention industry sector.

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Literature Review 2.1 Artificial Intelligence (AI)

Artificial intelligence (AI) is the ability of digital computers or robots controlled by computer devices to perform tasks that are typically carried out by living beings. The work of developing systems that encompass human intellectual traits, such as reasoning, understanding, generalisation, and even learning from past experiences, is often referred to as the definition of AI. This is reinforced by experts Russell and Norvig, who state that in everyday life, the term "artificial intelligence" is generally used to describe machines (or computers) that mimic human cognitive functions and have a connection with human thought, such as problem-solving and learning. [12]. John McCarthy then explained that artificial intelligence is a part of computer science that models human thinking processes and designs machines that can imitate human behaviour [13].

(Directorate General of Intellectual Property, Ministry of Law and Human Rights of the Republic of Indonesia, 2023) AI is defined as "a technology derived from computer programs based on data that aims to perform various tasks such as thinking, managing, and making decisions like humans." Thus, it can be said that AI technology is intelligent and sophisticated, and can learn from data to perform actions far better than humans. Technically, artificial intelligence is a field of computer science that studies the process of automating intelligent behaviour, or a field of computer science that focuses on creating software and hardware that can mimic some functions of the human brain. In reality, the discovery and utilisation of artificial intelligence have taken a long time and occurred in seven stages.

Programmers must have full control over the system because computer program machines work like humans due to weak AI. Since weak AI systems are designed to assist humans, they are not fully considered unintelligent or autonomous. Because input and output programs are based on humans, the shortcomings of AI do not pose copyright protection issues. The British music company JukeDeck, which was acquired by TikTok, uses a powerful AI model to create music and offers AI music services to its customers for use in various contexts, such as games and business. The AI neural network system generates music by learning from examples of flower pots.

2.2 Expert System

Andriani (2017:9) explains that an expert system is a system whose performance adopts the expertise possessed by an expert in a specific field into a computer system or program presented with an interface that can be used by non-expert users, so that with the system, users can make decisions or determine policies like an expert. Expert systems are one of the several problem domains or areas of Artificial Intelligence (AI). According to Professor Edward Feigenbaum in Rosnelly (2012:2), he defines expert systems as "an intelligent computer program that utilises knowledge and inference procedures to solve problems that are complex enough to require specialised human expertise.".

Expert systems are systems that attempt to adopt human knowledge into computers, so that computers can solve problems as experts do. A good expert system is designed to solve a specific problem by mimicking the work of experts. (Kusumadewi, 2003:109).

Characteristics of expert systems are as follows:

1) Limited to a specific domain of expertise.
2) Capable of providing reasoning for uncertain data.
3) Able to present a series of reasons in an understandable manner.
4) Based on certain rules.
5) Designed to be developed gradually.

$$CF_n = CF\ Pakar \times CF\ User$$

$$CF_{combine=}\ CF_1 + CF_2\ (1 - CF_1)$$

Explanation

CF_n : CF value of symptom n

$CF_{combine}$: CF value of skin type

2.3 Certainty Factor

Certainty Factor is a certainty factor to prove the disbelief in expert thinking, where experts need a certainty factor to describe the level of confidence, usually the result of the certainty factor method in the form of a percentage. Certainty factor uses values to estimate the expert's confidence in the data (Cahyaningsih et al., 2021).

Based on several previous studies, this expert system research uses the certainty factor method. This method works by determining the level of certainty about a fact or rule. The certainty factor method argues like an expert and obtains a confidence value. The calculation process is carried out by multiplying the user's cf value with the expert's cf value, resulting in a combined or composite CF value. The highest combined CF value is the final decision value (Santi & Andari, 2019).

The certainty factor expresses confidence in an event (or fact or hypothesis) based on evidence (or expert judgement). There are several methods for using certainty factors to handle uncertainty in knowledge-based systems. One way is to assign a value of 1 or 100 to represent an absolute truth (full confidence) and a value of 0 for a definite lie. The theory of certainty introduces the concepts of trust and distrust that can be combined according to the following equation (Turban, et al., 2005): $CF\ (P, E) = MB\ (P, E) - MD\ (P, E)$

Where:

CF: Certainty factor

MB: Measure of belief

MD: Measure of disbelief

P: Probability
E: Evidence or event

The measure of confidence about a piece of knowledge information based on the conclusion provided by a human expert, for example, "This might be true" or "This is very unlikely." The certainty factor can be used in several ways:

1. Certainty Factor for rules with a single premise (single premise rules):
   $CF\ (P, E) = CF(E) * CF(rule)$
   Where:
   CF (E): Measure of confidence in a symptom
   CF (rule): Measure of confidence in a rule
2. Certainty Factor for rules with multiple premises: $CF\ (A\ AND\ B)$ = Minimum ($CF(A)$, $CF(B)$) $CF\ (rule)$
   Where:
   CF (A AND B): The confidence value in symptoms A and B
   CF (A): The confidence value in symptom A
   CF (B): The confidence value in symptom B
   CF (rule): The measure of confidence in the rule
3. Confidence Factor for rules with similarly concluded rules:
   $CF\ Combination\ (CF1, CF2) = CF1 + CF2 * (1 - CF1)$ Where:
   CF1: The value of the first CF
   CF2: The value of the second CF
   CF (rule): The expert's confidence measure in the rule

Certainty factor (cf) is a value to measure the expert's confidence. The highest value is +1.0 (definitely true), the lowest is -1.0 (definitely false). Positive values represent the degree of confidence, while negative values represent the degree of uncertainty. For example, if an expert states that some evidence is almost certainly true, then a cf value of 0.8 will be given to this evidence.

Table 1. CF Value Interpretation

Uncertain Term	CF
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 0.6
Probably	0.8
Almost certainly	1.0
Definitely	

Certainty Factor (CF) shows the degree of certainty regarding a fact or rule. The notation for the Certainty Factor (Sri Kusumadewi, 2003) is as follows:
CF[h,e] = MB[h,e] - MD[h,e], where
CF[h,e]: Certainty Factor
MB[h,e]: the measure of confidence in hypothesis h, given evidence e (between 0 and 1). MD[h,e]: the measure of disbelief in hypothesis h, given evidence e (between 0 and 1). Rule Combination The MYCIN method for combining evidence on the antecedent of a rule is shown in the following table:

Table 2. MYCIN Combination Rules

Evidence, E	Antecedent Uncertainty

E1dan E2	Min [CF (H, E1), CF (H,
E1OR E2	Max [CF (H, E1), CF (H,
NOT E	- CF (H, E)

The basic form of the certainty factor formula for a rule IF E THEN H is as follows:
CF(H,e) = CF(E,e) * CF (H, E)
Where:
CF(E,e): Certainty Factor of evidence E influenced by evidence e
CF (H, E): Certainty Factor of the hypothesis assuming evidence is known with certainty, i.e., when CF(E,e) = 1
CF(H,e): Certainty Factor of the hypothesis influenced by evidence e If all evidence and antecedents are known with certainty, the formula becomes
CF(H,e) = CF (H, E)
In the diagnosis of a disease, the relationship between symptoms and hypotheses is often uncertain. It is very possible for several rules to produce one hypothesis and for one hypothesis to become evidence for another rule. The condition can be illustrated in Figure 1.

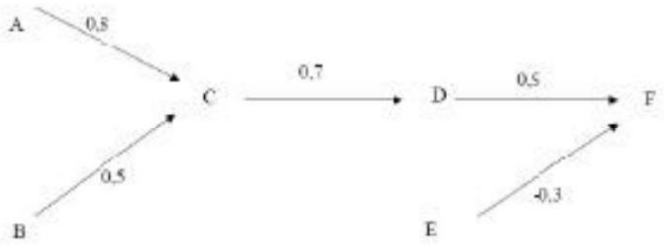


Figure 1. Certainty Factor Reasoning Network

Research Methodology

The research methodology used in this study is an applied research method with a quantitative-descriptive approach, aimed at designing and implementing an expert system to analyse the financial budget of PT. X using the Certainty Factor method. The research begins with the identification of problems through observation of the ongoing budget analysis process, followed by data collection through interviews with authorised personnel, such as financial staff and relevant managers, documentation studies of budget reports, and literature studies related to expert systems, budget analysis, and the Certainty Factor method. The data obtained are then analysed to determine the variables, indicators, and criteria that form the basis for compiling the expert system knowledge base. This knowledge base includes facts, symptoms, financing parameters, and decision rules that represent expert knowledge in assessing the reasonableness or potential issues in the budget.

The next stage is the design and development of the expert system, which includes the preparation of the database structure, interface design, formation of inference rules, and the application of the Certainty Factor method to calculate the confidence level in the budget analysis results. The Certainty Factor method is used to accommodate elements of uncertainty in the assessment, allowing the system to provide outputs in the form of confidence levels regarding indications of efficiency, discrepancies, or potential budgetary waste. Once the system is fully developed, testing is conducted using PT. X's budget data to assess the accuracy level, the alignment of the system's results with expert opinions, and the system's effectiveness in supporting decision-making. The test results are then analysed as a basis for drawing conclusions about the feasibility of implementing a Certainty Factor-based expert system to assist in the financial budget analysis process at PT. X.

Results

In this study, the analysis of the shopping financial budget at PT. X was conducted using an expert system approach with the Certainty Factor method to determine the main causes of inaccuracies or budget overruns. The calculation process begins by identifying symptoms or indicators that appear in the budget data, then each symptom is assigned a confidence weight by experts and a user confidence level. The Certainty Factor value for each symptom is calculated using the formula:

$$CF\ (H, E) = CF_{Exper} \times CF_{user}$$

Next, if there is more than one symptom in a single cause, the Certainty Factor values are combined using the formula:

$$CF_{combine} = CF_1 + CF_2 \times (1 - CF_1)$$

The formula is applied sequentially until all symptoms for one cause are fully calculated.

Table 3. Table of Symptoms/Indicators for Budget Expenditure Analysis

Code	Symptoms/Indicators
G01	The realisation of expenditures exceeded the established budget.
G02	There are expenses outside the budget plan.
G03	Procurement of goods/services does not align with priority needs.
G04	The frequency of budget revisions is too often.
G05	The difference between the planned and actual spending is not stable every month.
G06	Operational costs have increased significantly.
G07	Cash flow for routine needs is starting to be disrupted.
G08	Payments to vendors or obligations are often delayed.
G09	The budget control report was not prepared on time.
G010	The realisation of expenditures is still in line with the budget.
G011	Expenditures are dominated by priority needs.
G012	Monitoring and budget evaluation are conducted regularly.

Table 4. System Analysis/Conclusion Results

Code	Analysis Results
K01	Controlled budget
K02	The budget is out of control.
K03	Uncontrolled spending budget

Next, processing is carried out on the values used to indicate the user's confidence level when selecting symptoms.

Table 5. User Certainty Factor Value

User's Response	User CF Value
No	0.0
Not very sure	0.2
A little confident	0.4

Pretty sure	0.6
Sure	0.8
Very Confident	1.0

Then, it is formed on the basis of rules for each value that becomes part of the symptoms and CF Expert Rule for K01 – Controlled Expenditure Budget IF G10 AND G11 AND G12 THEN K01.

Table 6. Knowledge Base of Rules

Symptom	CF Expert
G10	0.8
G11	0.7
G12	0.6

The next stage involves rule-based knowledge for Rule K02 – Uncontrolled Spending Budget IF G02 AND G04 AND G05 AND G06 AND G09 THEN K02

Table 7. Rule for K02 – Uncontrolled Spending Budget

Symptom	CF Expert
G02	0.6
G04	0.7
G05	0.6
G06	0.7
G09	0.5

In the next stage, a table was created for the Rule for K03 – Uncontrollable Expenditure Budget IF G01 AND G02 AND G04 AND G06 AND G07 AND G08 AND G09 THEN K03

Table 8. Rule for K03 – Uncontrolled Expenditure Budget

Symptom	CF Expert
G01	0.8
G02	0.6
G04	0.6
G06	0.8
G07	0.8
G08	0.7
G09	0.5

Table 9. Condition Symptoms

Code	Selected Symptoms	User's Response	CF User
G01	Expenditure realisation exceeds the budget	Sure	0.8
G02	There are expenses beyond the plan.	Pretty sure	0.6
G04	Budget revisions too often	Sure	0.8

G06	Operational costs have increased significantly.	Pretty sure	0.6
G07	The cash flow for routine needs is disrupted.	Sure	0.8
G09	The budget control report is late.	A little confident	0.4

A. Calculation for K03 – Uncontrollable Expenditure Budget

Because the selected symptoms mostly point to K03, it is calculated as follows:

Step 1: Calculate the CF for each symptom

$$CF(G02) = 0.6 \times 0.6 = 0.36$$
$$CF(G04) = 0.6 \times 0.8 = 0.48$$
$$CF(G06) = 0.8 \times 0.6 = 0.48$$
$$CF(G07) = 0.8 \times 0.8 = 0.64$$
$$CF(G09) = 0.5 \times 0.4 = 0.20$$

Step 2: Combine the CF values

Combination 1

$$CF_{1,2} = 0.64 + 0.36(0.36)$$
$$CF_{1,2} = 0.64 + 0.1296 = 0.7696$$

Combination 2

$$CF_3 = 0.48$$
$$CF_{1,2,3} = 0.7696 + 0.48(1 - 0.7696)$$
$$CF_{1,2,3} = 0.7696 + 0.48(0.2304)$$
$$CF_{1,2,3} = 0.7696 + 0.110592 = 0.880192$$

Combination 3

$$CF_{1,2,3,4} = 0.880192 + 0.48(0.119808)$$
$$CF_{1,2,3,4} = 0.880192 + 0.05750784 = 0.93769984$$

Combination 4

$$CF_{1,2,3,4,5} = 0.93769984 + 0.64(0.06230016)$$
$$CF_{1,2,3,4,5} = 0.93769984 + 0.0398721024 = 0.9775719424$$

Combination 5

$$CF_{final} = 0.9775719424 + 0.20(0.0224280576)$$
$$CF_{final} = 0.9775719424 + 0.00448561152$$
$$CF_{final} = 0.98205755392$$

Final results K03

$$0.98205755392 \times 100\% = 98.21\%$$

So, the system's confidence level in the conclusion "Uncontrollable Expenditure Budget" is 98.21%.

B. Comparative Calculation for K02 – Uncontrolled Expenditure Budget

The symptoms that match K02 from the above case are G02, G04, G06, and G09.

Step 1: Calculate the CF for each symptom

$$CF(G04) = 0.7 \times 0.8 = 0.56$$
$$CF(G06) = 0.7 \times 0.6 = 0.42$$
$$CF(G09) = 0.5 \times 0.4 = 0.20$$

Step 2: Combination

$$CF_{1,2} = 0.36 + 0.3584 = 0.7184$$
$$CF_{1,2,3} = 0.7184 + 0.42(1 - 0.7184)$$
$$CF_{1,2,3} = 0.7184 + 0.118272 = 0.836672$$
$$CF_{final} = 0.836672 + 0.20(1 - 0.836672)$$
$$CF_{final} = 0.836672 + 0.0326656 = 0.8693376$$

Final results K02
0.8693376×100%=86.93%

Based on manual calculations using the Certainty Factor method, the results for each symptom were obtained and can be seen in the following table:

Table 9. Condition Symptoms

Result Code	Result Name	CF Value	Percentage
K02	The budget is out of control.	0.8693	86.93%
K03	Uncontrolled spending budget	0.9821	98.21%

With a 98.21% confidence level, the algorithm determines that PT. X's financial expenditure budget is in an uncontrolled state because K03 has the highest CF value.

The K03 criterion, which is uncontrolled spending budget, had the greatest certainty value at 0.9821, or 98.21%, according to manual calculations using the Certainty Factor approach. This figure was calculated using a number of important indications, including actual spending that exceeded the budget, expenditures that went beyond the plan, frequent budget changes, higher operating costs, irregular cash flow, and delays in budget control reports. As a result, the expert system created can determine that PT. X's budget situation is uncontrollable. This outcome demonstrates that decision-makers can analyse the budget condition based on the degree of confidence from the emerging symptoms with the help of the Certainty Factor approach.

Conclusion

The Certainty Factor approach can be successfully used to support the analysis of the company's budget conditions, according to research on Expert Systems in Analysing the Financial Budget of PT. X Using the Certainty Factor approach. A variety of budgetary symptoms or signs, including real spending that exceeds the budget, unforeseen expenses, frequent budget changes, higher operating costs, disturbances in regular cash flow, and delays in budget control reports, are the basis for the system's construction. The system may produce quantifiable and logical analysis results by processing these symptoms through a rule basis established by professionals and then calculating their certainty levels using the Certainty Factor approach.

Manual calculations revealed that the uncontrolled spending budget category had the highest certainty value, with a CF value of 0.9821, or 98.21%, while the less regulated spending budget category had a CF value of 0.8693, or 86.93%. These findings show that PT. X's spending budget condition primarily falls into the uncontrolled category. Thus, this study demonstrates that the Certainty Factor-based expert system may be used as a decision-making tool that improves the precision, speed, and objectivity of the company's financial expenditure budget analysis.

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