

# Analyzing Decision Support System for Determining Eligibility of Home Ownership Loan Using Fuzzy Mamdani Logical Method and Technology Acceptance Model in Banking

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**Abstract.** Every year, the number of people who want to own a house by credit increase, therefore the chances of increasing problem loans will be greater. Non-Performing Loan (NPL) is an indicator to assess the performance of bank functions. The higher the NPL value, the performance of the bank is considered worse. In order to maintain the caution of banks (creditors) in the provision of credit, the bank needs to assess and determine the criteria of debtors who can be given credit. So the bank can make decisions precisely and accurately. In this research, the Researcher will design decision support system with Mamdani fuzzy logic method with the resulted output in the form of "rejected" or "approved" decision. The accuracy rate in this study is 98%. 2% of the difference consists of 63.64% is a debtor with NPL credit status (problematic). After the system was designed in this study, the researcher conducted an analysis to see the user behavior when using the system. The method used is Technology Acceptance Model (TAM). The result of TAM analysis is the simultaneous relationship among of all variables on the acceptance of information technology (acceptance of IT) have a positive impact. However, a partial relationship between perceived usefulness and attitude toward using does not have a positive effect.

**Keyword:** Decision Support System, Fuzzy Mamdani, Matlab, Technology Acceptance Model (TAM)

**Abstrak.** Setiap tahun, jumlah orang yang ingin memiliki rumah sendiri dengan kredit meningkat, sehingga kemungkinan masalah yang terjadi pada proses pinjaman akan lebih besar. Non-Performing Loan (NPL) merupakan indikator untuk menilai pelaksanaan fungsi bank. Semakin tinggi nilai NPL, kinerja bank dianggap lebih buruk. Untuk menjaga keamanan proses penyediaan kredit, bank perlu menilai dan menentukan kriteria debitur yang dapat diberikan kredit agar bank dapat membuat keputusan yang tepat dan akurat. Dalam penelitian ini, peneliti akan merancang sistem pendukung keputusan dengan metode logika fuzzy Mamdani dengan menghasilkan output berupa "rejected" atau "approved". Tingkat akurasi dalam studi ini adalah 98%. 2% ketidakakuratan ini disebabkan 63.64% adalah debitur dengan NPL kredit status (bermasalah). Setelah sistem ini dirancang, peneliti melakukan analisis untuk melihat perilaku pengguna ketika menggunakan sistem. Metode yang digunakan adalah Technology Acceptance Model (TAM). Hasil analisis TAM adalah adanya hubungan simultan antara semua variabel. Penggunaan teknologi informasi memiliki dampak positif. Namun, hubungan parsial antara manfaat dan sikap pengguna tidak memiliki efek positif.

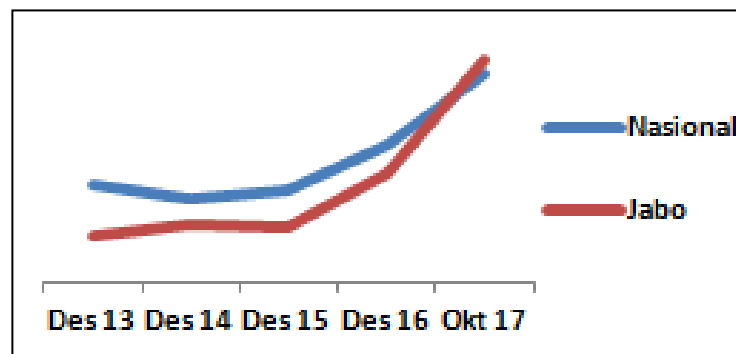
**Kata Kunci:** Sistem Pendukung Keputusan, Fuzzy Mamdani, Matlab, Technology Acceptance Model (TAM)

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## 1. Introduction

Home Ownership Loan (KPR) is one way to fulfill the needs of the home and long-term investment. Every year, the more people who want to own the house and invest, the more problematic credit opportunities will be. This affects the NPL value of a bank (creditor). Non-Performing Loans (NPLs) or non-performing loans are indicators for assessing bank function performance. The higher the NPL value, the performance of the bank is considered worse. The progress of NPL KPR BCA both National and Jabodetabek can be seen in Figure 1.



**Figure 1** The Progress of NPL KPR BCA Graphic

One of the causes of problem loans is less precise in determining the debtor who deserves credit. The accuracy in giving credit to debtors greatly influences the magnitude of NPLs in the future. In order to maintain the caution of banks (creditors) in the provision of credit, banks need to assess and determine the criteria of debtors who can be given credit. So that banks can make decisions accurately and accurately. To achieve this, it takes a decision support system (DSS) to produce a decision accurately and accurately. The Researcher uses a settlement method that is fuzzy mamdani technique support the system. This method has a simple concept and easy to understand, but can produce decisions accurately and accurately. In this research will be built a prototype decision support system of creditworthiness with GUI-based, then will be analyzed the positive impact given by the user to the system built in producing an accurate and objective decision. To measure the acceptance of information systems to users of decision support systems built using the Technology Acceptance Model (TAM) method. The constructs used in this research are perceived usefulness, perceive ease of use, attitude towards using and acceptance of IT. The problem limitation in this research as follows:

1. This research is conducted to grant housing loan from PT. Bank Central Asia, Tbk in Jabodetabek.
2. Method in this research is Fuzzy Mamdani method.
3. Technological Acceptance Model (TAM) method constructs used to assess acceptance of decision support systems are: perceived usefulness, perceived ease of use, attitude towards using and acceptance of IT.

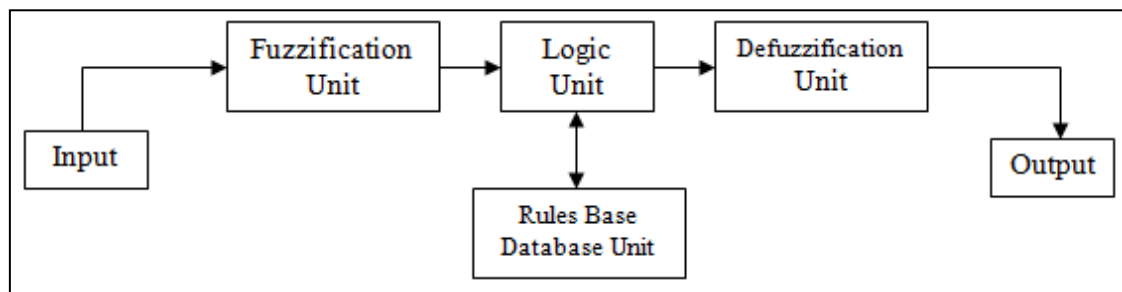
## 2. Theoretical Framework

### 2.1 Decision Support System

Turban and Aroson (2001), stated that the concept of Decision Support System (DSS) first appeared in the early 1970s by Scott-Morton. They define DSS as a computer-based interactive system that can assist decision makers in using data and models to solve unstructured problems.

### 2.2 Fuzzy Logic

Fuzzy logic was first introduced by prof. Lotfi A. Zadeh in 1965. Fuzzy means blurred or vague. Fuzzy logic is a multivalued logic that makes it possible to define intermediate values between two different logics, such as true and false, high and low, heat and cold, and others (Kusumadewi and Purnomo, 2004). Steps of fuzzy process is shown in Figure 2.



**Figure 2** Fuzzy Process

#### A. Mamdani Method

According to Kusumadewi et al. (2006), Mamdani method is often also known as min-max method. This method was introduced by Ebrahim Mamdani in 1975. Mamdani's method is most often used in applications because it has a simple structure, that is, using min-max or max-product operation. The process to get the output required the following four stages:

1. Fuzzification

Fuzzification is the process of changing the input value firmly into a fuzzy input value.

2. Creation of Fuzzy Rules

Fuzzy rules are established to get a firm output. The fuzzy rule used is the "if-then" rule with the operator between the input variables is the "and" operators. Statements that follow "if" are referred to as antecedent and statements that follow "hence" are called consequent.

3. Fuzzy Logic Analysis

Every rule formed is a statement of implications. The fuzzy logic analysis used in this step is the min implication function, since the operators used in the "if-then" rule are the "and" operators. The result of the implication function of each rule is called  $\alpha$ -predicate or commonly written  $\alpha$ .

$$\alpha_i = \mu_{A \cap B} = \min(\mu_{A_i}(x), \mu_{B_i}(y)) \quad (1)$$

Furthermore, the max method is done inference fuzzy system, the composition between rules. The composition of the rules is the overall conclusion by taking the maximum membership level of each consequent application of the implication function and combining from all the conclusions of each rule, so that the fuzzy solution area is obtained as follows:

$$\mu_{sf} [x_i] = \max (\mu_{sf} [x_i], \mu_{kf}[x_i]) \quad (2)$$

#### 4. Defuzzification

Defuzzification is a method to map the value of the fuzzy set into the crisp value. This research uses the method of centroid. Crisp settlement method is obtained by taking the center point (Z) fuzzy area, that is by formula:

$$Z = \frac{\int \mu(z).z .dz}{\int \mu(z).dz} \quad (3)$$

### 2.3 Home Ownership Loan (KPR)

KPR is a credit used to buy a home or for other consumer needs with a home guarantee. Although the use is similar, KPR is different from construction and renovation credits.

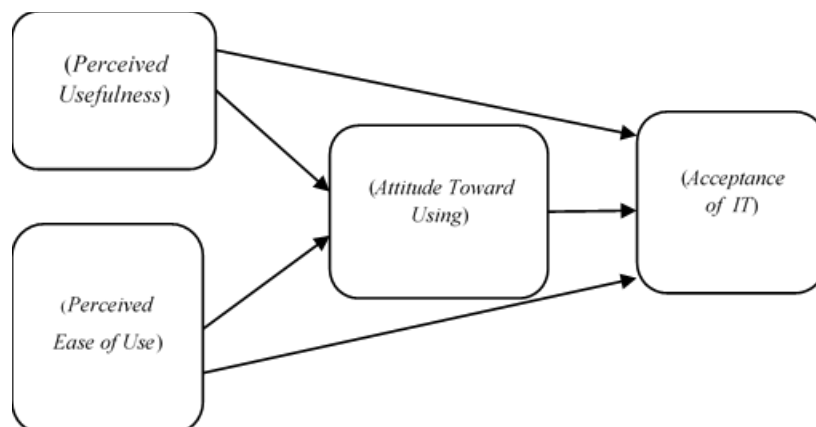
### 2.4 Non-Performing Loan (NPL)

According to Apriani (2011), Non-Performing Loan is a condition in which the customer is unable to pay part or all of its obligations to the bank as has been agreed. Meanwhile, according to Bank Indonesia in May 1993 deregulation policy package (PAKMEI 1993), non-performing loans are credits classified into Sub-standard Collectibility, Doubtful (D) and Loss (M).

### 2.5 Technology Acceptance Model (TAM)

Davis et al (1989) stated that the Technology Acceptance Model (TAM) is a theory of information systems that makes models about user processes willing to accept and use technology. This model explains that when users use information systems, a number of factors influence their decision on how and when to use the information system.

The basic model of technology acceptance in Technological Acceptance Model (TAM) is shown in Figure 3, as follows:



**Figure 3** Technology Acceptance Model [1]

### 3. Research Method

#### 3.1 Identification of Assessment Criteria

In crediting KPR from BCA in Jakarta, there are criteria to be assessed in the credit analysis as follows.

1. Income
2. Business Type
3. Collateral Value
4. Household expenses
5. Other Credits
6. Age
7. Plafond
8. Tenor
9. LTV (Loan To Value)
10. Interest Rate
11. Business Risk

The "business risk" criterion is an additional criterion proposed by researchers in the process of credit analysis of mortgages that are expected to produce an appropriate and accurate decision.

#### 3.2 Research Construct Indicators

In this research, the indicators used to measure each construct are presented in Table 1.

**Table 1** Indicators of research construct

No	Construct	Indicator
1	<i>Perceived usefulness</i>	<ol style="list-style-type: none"> <li>1. Useful</li> <li>2. Simplify the job</li> <li>3. Increase Productivity</li> <li>4. Efficiency</li> <li>5. Effectiveness</li> </ol>
2	<i>Perceived ease of use</i>	<ol style="list-style-type: none"> <li>1. Easy to learn</li> <li>2. Easy to use</li> <li>3. Easy to control</li> <li>4. Easy to understand</li> <li>5. Flexibility</li> </ol>
3	<i>Attitude toward using</i>	<ol style="list-style-type: none"> <li>1. Believe</li> <li>2. A lot of benefits</li> <li>3. Easy to operate</li> <li>4. Good Idea</li> <li>5. Fun</li> </ol>
4	<i>Acceptance of IT</i>	<ol style="list-style-type: none"> <li>1. Attitude to the presence of system</li> <li>2. Happy attitude to the system</li> <li>3. Satisfied attitude to the system</li> <li>4. Display</li> <li>5. Enthusiasm</li> </ol>

### 3.3 Flowchart

The flowchart design of the decision support system of the feasibility of providing KPR can be seen in Figure 4, and flowchart of Fuzzy Mamdaniin Figure 5.

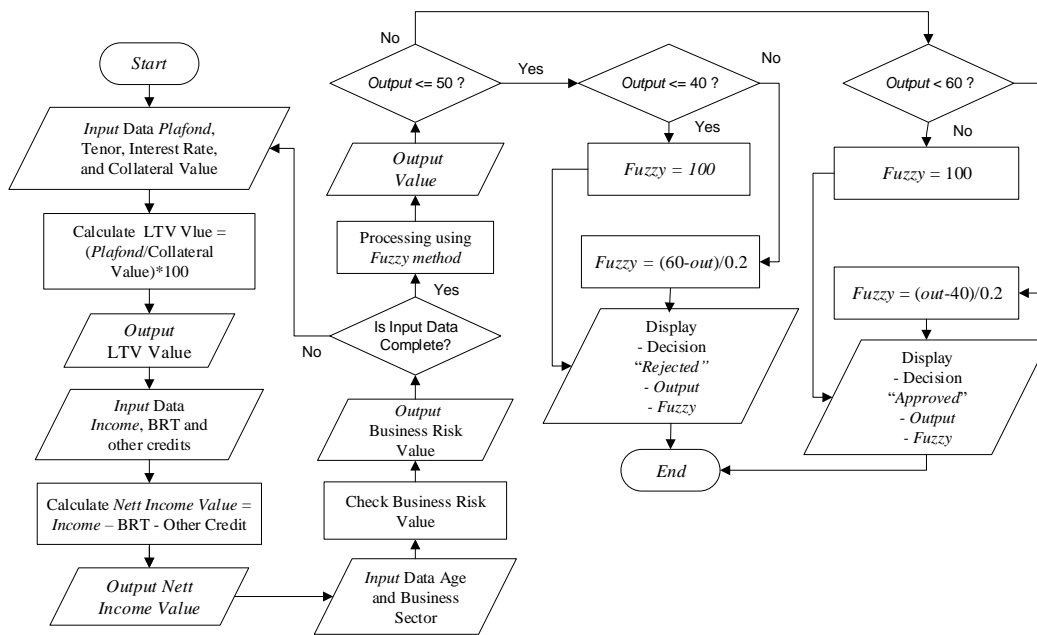


Figure 4 DSS of the Feasibility of providing KPR

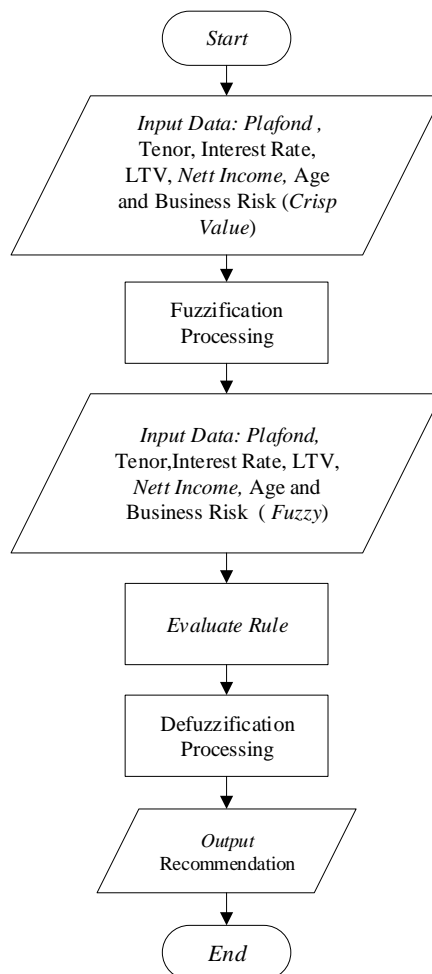


Figure 5 Fuzzy Mamdani Process

### 3.4 User Interface System

In this study, the user interface is built using the GUI. Figure 6 shows the image of the debtor data input page as well as the result.

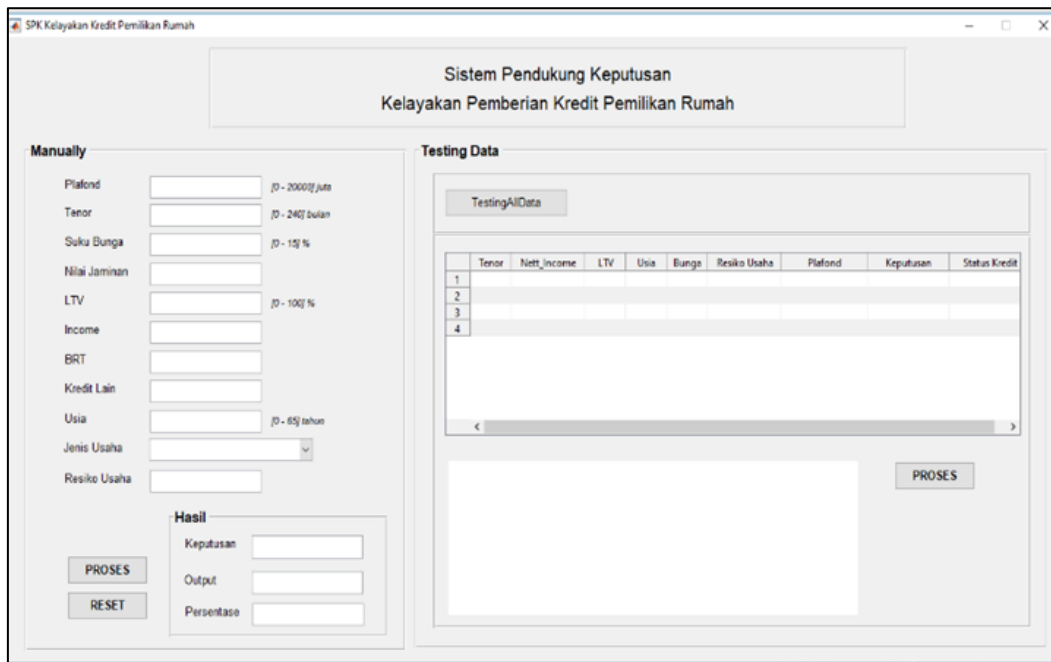


Figure 6 User Interface System

## 4. Result and Discussion

### 4.1 Defining Variabels

#### 1. Input Plafond Variable

Table 2 Input Plafond Variable

Variable	FuzzyInput	Range	Domain	Parameter
Plafond	Very small		[0 600]	[0 0 400 600]
	Small		[400 1100]	[400 600 900 1100]
	Average	0-20000	[900 2100]	[900 1100 1900 2100]
	Large		[1900 10100]	[1900 2100 9900 10100]
	Very Large		[10000 20000]	[9900 10100 20000 20000]

The equation of membership function for the plafond input variable is expressed in this equation:

$$\begin{aligned}
\mu_{Sangat\ Kecil} &= \begin{cases} 1 & ; 0 \leq x \leq 400 \\ \frac{600-x}{600-400} & ; 400 < x < 600 \\ 0 & ; x \geq 600 \end{cases} \\
\mu_{Kecil} &= \begin{cases} \frac{x-400}{600-400} & ; 400 \leq x < 600 \\ 1 & ; 600 \leq x \leq 900 \\ \frac{1100-x}{1100-900} & ; 900 < x \leq 1100 \end{cases} \\
\mu_{Sedang} &= \begin{cases} \frac{x-900}{1100-900} & ; 900 \leq x < 1100 \\ 1 & ; 1100 \leq x \leq 1900 \\ \frac{2100-x}{2100-1900} & ; 1900 < x \leq 2100 \end{cases} \\
\mu_{Besar} &= \begin{cases} \frac{x-1900}{2100-1900} & ; 1900 \leq x < 2100 \\ 1 & ; 2100 \leq x \leq 9900 \\ \frac{10100-x}{10100-9900} & ; 9900 < x \leq 10100 \end{cases} \\
\mu_{Sangat\ Besar} &= \begin{cases} 0 & ; x < 9900 \\ \frac{x-9900}{10100-9900} & ; 9900 \leq x < 20000 \\ 1 & ; x \geq 20000 \end{cases}
\end{aligned}$$

## 2. Input Tenor Variable

**Table 3** Variabel Input Tenor

Variable	FuzzyInput	Range	Domain	Parameter
Tenor	Short	0 - 240	[0 80]	[0 0 40 80]
	Medium		[40 140]	[40 80 100 140]
	Long		[100 240]	[100 140 240 240]

The equation of membership function for the tenor input variable is expressed using this equation:

$$\begin{aligned}
\mu_{Pendek} &= \begin{cases} 1 & ; 0 \leq x \leq 40 \\ \frac{80-x}{80-40} & ; 40 < x < 80 \\ 0 & ; x \geq 80 \end{cases} \\
\mu_{Sedang} &= \begin{cases} \frac{x-40}{80-40} & ; 40 \leq x < 80 \\ 1 & ; 80 \leq x \leq 100 \\ \frac{140-x}{140-100} & ; 100 < x \leq 140 \end{cases} \\
\mu_{Panjang} &= \begin{cases} 0 & ; x \leq 100 \\ \frac{x-100}{140-100} & ; 100 < x < 140 \\ 1 & ; x \geq 140 \end{cases}
\end{aligned}$$



## 3. Interest Rate Input Variable

**Table 4** Interest Rate Input Variable

Variable	Fuzzy Input	Range	Domain	Parameter
Interest Rate	Low	0-15	[0 7]	[0 0 5 7]
	Standard		[5 11]	[5 7 9 11]
	High	[9 15]	[9 11 15 15]	

The equation of membership function for the interest rate variable is expressed using the equation:

$$\mu_{Low} = \begin{cases} 1 & ; 0 \leq x \leq 5 \\ \frac{7-x}{7-5} & ; 5 < x < 7 \\ 0 & ; x \geq 7 \end{cases}$$

$$\mu_{Standard} = \begin{cases} \frac{x-5}{7-5} & ; 5 \leq x < 7 \\ 1 & ; 7 \leq x \leq 9 \\ \frac{11-x}{11-9} & ; 9 < x \leq 11 \\ 0 & ; x \leq 9 \end{cases}$$

$$\mu_{High} = \begin{cases} 0 & ; x \leq 9 \\ \frac{x-9}{11-9} & ; 9 < x < 11 \\ 1 & ; x \geq 11 \end{cases}$$

## 4. LTV Input Variable

**Table 5** LTV Input Variable

Variable	Input Fuzzy Set	Range	Domain	Parameter
LTV	Small	0-100	[0 55]	[0 0 45 55]
	Standard		[45 90]	[45 55 80 90]
	Big	[80 100]	[80 90 100 100]	

The equation of membership function for the LTV input variable is expressed using this equation:

$$\mu_{Kecil} = \begin{cases} 1 & ; 0 \leq x \leq 45 \\ \frac{55-x}{55-45} & ; 45 < x < 55 \\ 0 & ; x \geq 55 \end{cases}$$

$$\mu_{Standard} = \begin{cases} \frac{x-45}{55-45} & ; 45 \leq x < 55 \\ 1 & ; 55 \leq x \leq 80 \\ \frac{90-x}{90-80} & ; 80 < x \leq 90 \\ 0 & ; x \leq 80 \end{cases}$$

$$\mu_{Besar} = \begin{cases} 0 & ; x \leq 80 \\ \frac{x-80}{90-80} & ; 80 < x < 90 \\ 1 & ; x \geq 90 \end{cases}$$

## 5. Nett Income Input Variable

**Table 6** Nett Income Input Variable

Variable	Fuzzy Input	Range	Domain	Parameter
Net Income	Very small		[0 10]	[0 0 8 10]
	Small	0-1000	[8 26]	[8 10 24 26]
	Average		[24 41]	[24 26 39 41]
	Big		[39 101]	[39 41 99 101]
	Very big		[99 1000]	[99 101 9000 9000]

The equation of membership function for input net income variable is expressed using equation:

$$\begin{aligned} \mu_{Sangat\ Kecil} &= \begin{cases} 1 & ; 0 \leq x \leq 8 \\ \frac{10-x}{10-8} & ; 8 < x < 10 \\ 0 & ; x \geq 10 \end{cases} \\ \mu_{Kecil} &= \begin{cases} \frac{x-8}{10-8} & ; 8 \leq x < 10 \\ 1 & ; 10 \leq x \leq 24 \\ \frac{26-x}{26-24} & ; 24 < x \leq 26 \end{cases} \\ \mu_{Sedang} &= \begin{cases} \frac{x-24}{26-24} & ; 24 \leq x < 26 \\ 1 & ; 26 \leq x \leq 39 \\ \frac{41-x}{41-39} & ; 39 < x \leq 41 \end{cases} \\ \mu_{Besar} &= \begin{cases} \frac{x-39}{41-39} & ; 39 \leq x < 41 \\ 1 & ; 41 \leq x \leq 99 \\ \frac{101-x}{101-99} & ; 99 < x \leq 101 \end{cases} \\ \mu_{Sangat\ Besar} &= \begin{cases} 0 & ; x < 99 \\ \frac{x-99}{101-99} & ; 99 \leq x < 101 \\ 1 & ; x \geq 101 \end{cases} \end{aligned}$$

## 6. Age Input Variable

**Table 7** Age Input Variable

Variabel	Fuzzy Input	Range	Domain	Parameter
Age	Young	0-65	[0 35]	[0 0 25 35]
	Middle-aged		[30 50]	[25 35 40 50]
	Old		[40 65]	[40 50 65 65]

The equation of the membership function for the age input variable is expressed using the equation:

$$\mu_{Muda} = \begin{cases} 1 & ; 0 \leq x \leq 25 \\ \frac{35-x}{35-25} & ; 25 < x < 35 \\ 0 & ; x \geq 35 \end{cases}$$

$$\mu_{Parobaya} = \begin{cases} \frac{x-25}{35-25} & ; 25 \leq x < 35 \\ 1 & ; 35 \leq x \leq 40 \\ \frac{50-x}{50-40} & ; 40 < x \leq 50 \\ 0 & ; x \leq 40 \end{cases}$$

$$\mu_{Tua} = \begin{cases} \frac{x-40}{50-40} & ; 40 < x < 50 \\ 1 & ; x \geq 65 \end{cases}$$

## 7. Business Risk Input Variable

**Table 8** Business Risk Input Variable

Variable	Fuzzy Input	Range	Domain	Parameter
Business Risk	Very small	0-100	[0 15]	[0 0 11 15]
	Small		[11 32]	[11 15 28 32]
	Average		[28 57]	[28 32 53 57]
	Big		[53 88]	[53 57 84 88]
	Very big		[84 100]	[84 88 100 100]

The formula equation of membership function for business risk input variable is expressed by the following equation:

$$\mu_{Sangat\ Kecil} = \begin{cases} 1 & ; 0 \leq x \leq 11 \\ \frac{15-x}{15-11} & ; 11 < x < 15 \\ 0 & ; x \geq 15 \end{cases}$$

$$\mu_{Kecil} = \begin{cases} \frac{x-11}{15-8} & ; 11 \leq x < 15 \\ 1 & ; 15 \leq x \leq 28 \\ \frac{32-x}{32-28} & ; 28 < x \leq 32 \end{cases}$$

$$\mu_{Sedang} = \begin{cases} \frac{x-28}{32-28} & ; 28 \leq x < 32 \\ 1 & ; 32 \leq x \leq 53 \\ \frac{57-x}{57-53} & ; 53 < x \leq 57 \end{cases}$$

$$\mu_{Besar} = \begin{cases} \frac{x-53}{57-53} & ; 53 \leq x < 57 \\ 1 & ; 57 \leq x \leq 84 \\ \frac{88-x}{88-84} & ; 84 < x \leq 88 \end{cases}$$

$$\mu_{Sangat\ Besar} = \begin{cases} 0 & ; x < 84 \\ \frac{x-84}{88-84} & ; 84 \leq x < 88 \\ 1 & ; x \geq 88 \end{cases}$$

8. Output Decision Variable

**Table 9** Output Decision Variable

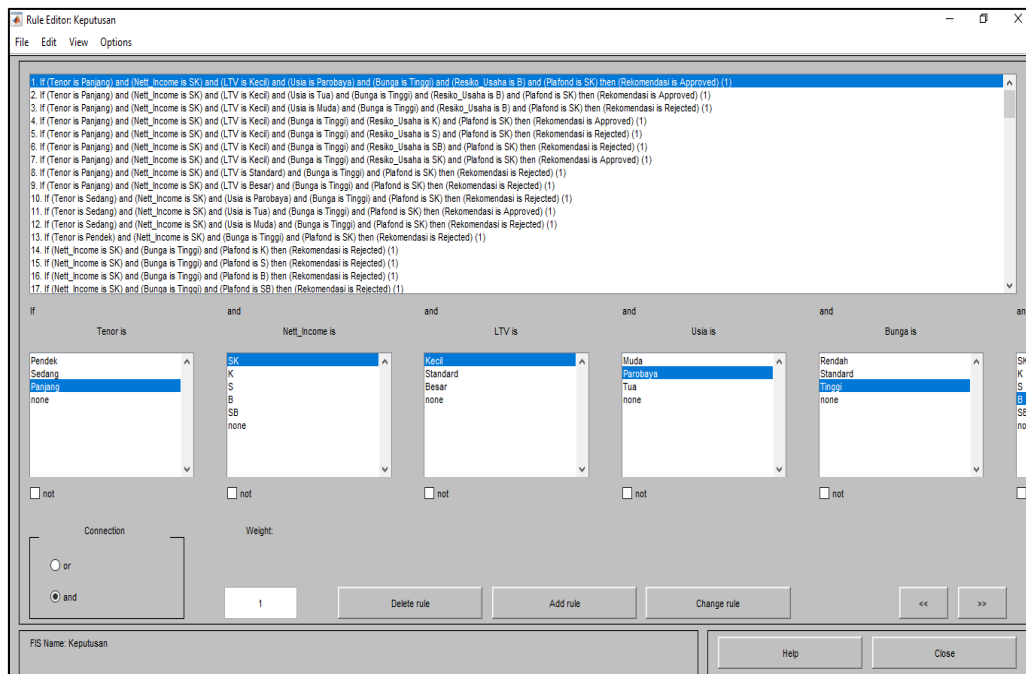
Variable	Fuzzy Input	Range	Domain	Parameter
Decision	<i>Rejected</i>	0-100	[0 60]	[0 0 40 60]
	<i>Approved</i>		[40 100]	[40 60 100 100]

The equation of the membership function for the decision output variable is expressed by the following equation:

$$\mu_{Rejected} = \begin{cases} 1 & ; 0 \leq x \leq 40 \\ \frac{x - 40}{60 - 40} & ; 40 < x < 60 \\ 0 & ; x \geq 60 \end{cases}$$

$$\mu_{Approved} = \begin{cases} 0 & ; x < 40 \\ \frac{100 - x}{100 - 40} & ; 40 \leq x < 60 \\ 1 & ; x \geq 60 \end{cases}$$

After the membership function, then the next step is the rule base. This rule base consists of a set of decision rules with fuzzy mamdani method to declare the debtor is accepted or rejected credit. The base rule is shown in Figure 7 below:



**Figure 7** Rule Based for Decision Making

After a rule is established, an application of the implication function is performed. The implication function used is MIN which means the membership level obtained from this process is the minimum value of the input variables to get the fuzzy area on the variable of the debtor's feasibility result for each rule.

## 4.2 Calculation of Mamdani Method

Based on the assessment sample of the debtor's feasibility, the implication function can be shown as follows:

Example:

Tenor = 168, Nett Income = 8,45, LTV = 54,19, Age = 40, Interest = 9,25, Risk = 90,5 and Plafond = 300

Thus, the membership value of each parameter is:

- a. Tenor :  $\mu_{\text{Long}} = 1$
- b. Nett Income :  $\mu_{\text{Very Small}} = \frac{10-8,45}{10-8} = 0,775$   
 $\mu_{\text{Small}} = \frac{8,45-8}{10-8} = 0,225$
- c. LTV :  $\mu_{\text{Small}} = \frac{55-54,19}{55-45} = 0,081$   
 $\mu_{\text{Standard}} = \frac{54,19-45}{55-45} = 0,919$
- d. Age :  $\mu_{\text{Middle-Aged}} = 1$
- e. Interest :  $\mu_{\text{Standard}} = \frac{11-9,25}{11-9} = 0,875$   
 $\mu_{\text{Hight}} = \frac{9,25-9}{11-9} = 0,125$
- f. Business Risk :  $\mu_{\text{Very Big}} = 1$
- g. Plafond :  $\mu_{\text{Very Small}} = 1$

So the implication function is as follows :

- a. Rule 23

$1;0,775;0,081;1;0,875;1;1 \rightarrow \text{Rejected}$

$$\begin{aligned} \alpha_{23} &= \min \{ \mu_{\text{Tenor}}(168), \mu_{\text{NettIncome}}(8,45), \mu_{\text{LTV}}(54,19), \mu_{\text{Age}}(40), \\ &\quad \mu_{\text{Interest}}(9,25), \mu_{\text{Risk}}(90,5), \mu_{\text{Plafond}}(300) \} \\ &= \min \{ 1;0,775;0,081;1;0,875;1;1 \} \\ &= 0,081 \end{aligned}$$

- b. Rule 6

$1;0,775;0,081;1;0,125;1;1 \rightarrow \text{Rejected}$

$$\begin{aligned} \alpha_6 &= \min \{ \mu_{\text{Tenor}}(168), \mu_{\text{NettIncome}}(8,45), \mu_{\text{LTV}}(54,19), \mu_{\text{Age}}(40), \\ &\quad \mu_{\text{Interest}}(9,25), \mu_{\text{Risk}}(90,5), \mu_{\text{Plafond}}(300) \} \\ &= \min \{ 1;0,775;0,081;1;0,125;1;1 \} \\ &= 0,081 \end{aligned}$$

- c. Rule 25

1;0,775;0,919;1;0,875;1;1  $\rightarrow$  *Approved*

$$\begin{aligned}\alpha_{25} &= \min \{ \mu_{\text{Tenor}}(168), \mu_{\text{NettIncome}}(8,45), \mu_{\text{LTV}}(54,19), \mu_{\text{Age}}(40), \\ &\quad \mu_{\text{Interest}}(9,25), \mu_{\text{Risk}}(90,5), \mu_{\text{Plafond}}(300) \} \\ &= \min \{ 1;0,775;0,919;1;0,875;1;1 \} \\ &= 0,775\end{aligned}$$

d. *Rule 8*

1;0,775;0,919;1;0,125;1;1  $\rightarrow$  *Approved*

$$\begin{aligned}\alpha_8 &= \min \{ \mu_{\text{Tenor}}(168), \mu_{\text{NettIncome}}(8,45), \mu_{\text{LTV}}(54,19), \mu_{\text{Age}}(40), \\ &\quad \mu_{\text{Interest}}(9,25), \mu_{\text{Risk}}(90,5), \mu_{\text{Plafond}}(300) \} \\ &= \min \{ 1;0,775;0,919;1;0,125;1;1 \} \\ &= 0,125\end{aligned}$$

e. *Rule 61*

1;0,225;0,919;1;0,875;1;1  $\rightarrow$  *Approved*

$$\begin{aligned}\alpha_{61} &= \min \{ \mu_{\text{Tenor}}(168), \mu_{\text{NettIncome}}(8,45), \mu_{\text{LTV}}(54,19), \mu_{\text{Age}}(40), \\ &\quad \mu_{\text{Interest}}(9,25), \mu_{\text{Risk}}(90,5), \mu_{\text{Plafond}}(300) \} \\ &= \min \{ 1;0,225;0,919;1;0,875;1;1 \} \\ &= 0,225\end{aligned}$$

f. *Rule 56*

1;0,225;0,919;1;0,125;1;1  $\rightarrow$  *Approved*

$$\begin{aligned}\alpha_{56} &= \min \{ \mu_{\text{Tenor}}(168), \mu_{\text{NettIncome}}(8,45), \mu_{\text{LTV}}(54,19), \mu_{\text{Age}}(40), \\ &\quad \mu_{\text{Interest}}(9,25), \mu_{\text{Risk}}(90,5), \mu_{\text{Plafond}}(300) \} \\ &= \min \{ 1;0,225;0,919;1;0,125;1;1 \} = 0,125\end{aligned}$$

Composition rule function implication using MAX. It uses a way of taking the maximum value from the rule output. Max method is used to specify the composition of rules.

Output variable :

Degree of group correctness *Rejected*

$$\begin{aligned}&= \max (\alpha_6; \alpha_{23}) \\ &= \max (0,081; 0,081) \\ &= 0,081\end{aligned}$$

Degree of group correctness *Approved*

$$\begin{aligned}&= \max (\alpha_8; \alpha_{25}; \alpha_{56}; \alpha_{61}) \\ &= \max (0,125; 0,775; 0,125; 0,225) \\ &= 0,775\end{aligned}$$

Based on the membership function of the output of rejected variable,  $\alpha_6$  obtained the value of 0.081 d (6) as follows:

$$\begin{aligned}\mu_R(d6) = \alpha 6 &\leftrightarrow \frac{d(6)-40}{60-40} = 0,081 \\ d(6) - 40 &= 1,62 \\ d(6) &= 41,62\end{aligned}$$

Based on the membership function of the approved output variable at  $\alpha 8$ , the value of 0.775  $d(8)$  is obtained as follows:

$$\begin{aligned}\mu_R(d8) = \alpha 8 &\leftrightarrow \frac{100-d(8)}{100-40} = 0,775 \\ 100 - d(8) &= 46,5 \\ d(6) &= 53,5\end{aligned}$$

Modified high membership function of the output variable after applied  $\alpha$  cut is:

$$\mu(z) = \begin{cases} 0,081 & ; z \leq 41,62 \\ 0,667 & ; z \geq 53,5 \end{cases}$$

Next at the defuzzification stage, the Researcher make a calculation process using the method of centroid, as follows:

$$\begin{aligned}M_1 &= \int_0^{41,62} (0,081)z \, dz = \frac{0,081}{2} (41,62^2 - 0^2) = 70,155 \\ M_2 &= \int_{53,5}^{100} (0,667)z \, dz = \frac{0,667}{2} (100^2 - 53,5^2) = 2380,44 \\ A_1 &= \int_0^{41,62} 0,081 \, dz = 3,371 \\ A_2 &= \int_{53,5}^{100} 0,667 \, dz = 66,7 - 35,685 = 31,015\end{aligned}$$

So, the *crisp output* value is :

$$Z = \frac{M_1 + M_2}{A_1 + A_2} = \frac{70,155 + 2380,44}{3,371 + 31,015} = \frac{2450,595}{35,327} = 69,37$$

Output limits:

Assessment “*Rejected*” : value limit *output*  $\leq 50$

Assessment “*Approved*” : value limit *output*  $> 50$

So it can be concluded with existing data and after analyzed, the data used as samples are categorized to provide credit worthiness assessment with a value of 69.37.

### 4.3 Assessment and Analysis

#### 4.3.1. Prototype Assessment

Testing is performed in 2 ways, namely by testing data and with manual. The following display of data and manual testing results can be seen in Figure 8 and Figure 9:

##### a. Testing Data Result

The screenshot shows a software interface titled "Testing Data". At the top, there is a button labeled "TestingAllData". Below it is a table with 9 rows of data. The columns are: No, Usia, Bunga, Resiko Usaha, Plafond, Keputusan, Status Kredit, and Hasil Penghitungan. Below the table, there is a section titled "=== Run information ===" containing the following text:

```
Instances = 500
Correctly Classified Instances = 489    Akurasi 98 %

Terdapat = 7 data yang Approved-Rejected-NPL
dari 11 data yang Approved-Rejected    63.64 %

Saved rejected file = "500apperror.xlsx"
Saved rejected-NPL file = "500appbermasalaherror.xlsx"
```

At the bottom right of the interface is a button labeled "PROSES".

No	Usia	Bunga	Resiko Usaha	Plafond	Keputusan	Status Kredit	Hasil Penghitungan
1	34	9.50	28.90	400.00	Approved	NPL	APPROVED
2	39	10.00	45.60	350.00	Approved	NPL	APPROVED
3	25	8.50	16.80	214.77	Approved	NPL	APPROVED
4	40	9.25	90.50	300.00	Approved	NPL	APPROVED
5	40	9.25	90.50	300.00	Approved	NPL	APPROVED
6	41	8.80	82.80	752.50	Approved	NPL	APPROVED
7	49	10.00	77.30	150.00	Approved	NPL	APPROVED
8	43	9.50	28.90	368.80	Approved	NPL	APPROVED
9	43	9.50	28.90	368.80	Approved	NPL	APPROVED

Figure 8 Testing Data Result

##### b. Manual Result

The screenshot shows a software interface titled "Manually". It contains several input fields for parameters, each with a corresponding range or unit:

- Plafond: 300 [0 - 20000] juta
- Tenor: 120 [0 - 240] bulan
- Suku Bunga: 7 [0 - 15] %
- Nilai Jaminan: 500
- LTV: 60 [0 - 100] %
- Income: 8
- BRT: 2
- Kredit Lain: 0
- Usia: 25 [0 - 65] tahun
- Jenis Usaha: Banking (dropdown menu)
- Resiko Usaha: 36.5

At the bottom left, there are two buttons: "PROSES" and "RESET". At the bottom right, there is a section titled "Hasil" (Result) with three output fields:

- Keputusan: APPROVED
- Output: 72.6757
- Persentase: 100

Figure 9 Manual Result



After done if the data sample as much as 500 data, hence done comparison between result of DSS testing with method fuzzy Mamdani with original data. The comparative results can be seen in Figure 10 below.

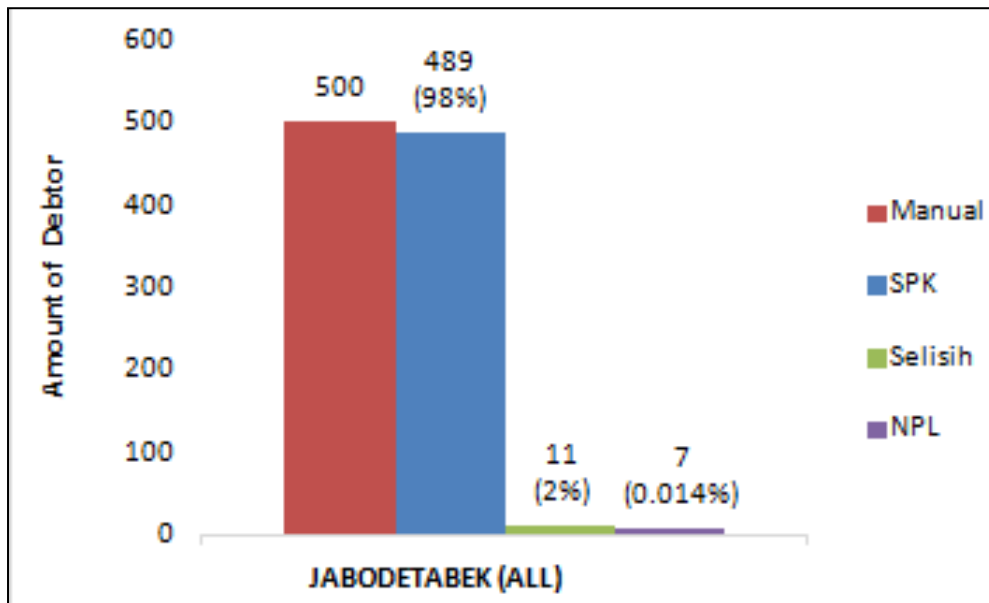


Figure 10 Comparative Graph of DSS With Original Data

Based on the information in Figure 11, the result of comparison between DSS with the Mamdani fuzzy method with the original data visible to the accuracy of DSS is 98%. There are 11 data that give different results with the original data of 500 data used. From 11 different data, there are 7 data or 63,64% which is NPL debtor. So it can be said that DSS with fuzzy Mamdani method produces more accurate decision on this research.

### 4.3.2 Hypothesis Testing

Hypothesis testing is done by using path analysis as the development of multiple regression analysis with significance level = 0.05. There are two substructures that must be tested that are:

1. Substructure 1, test the influence of perceived usefulness ( $X_1$ ), perceived ease of use ( $X_2$ ) to attitude toward using ( $Y$ ).

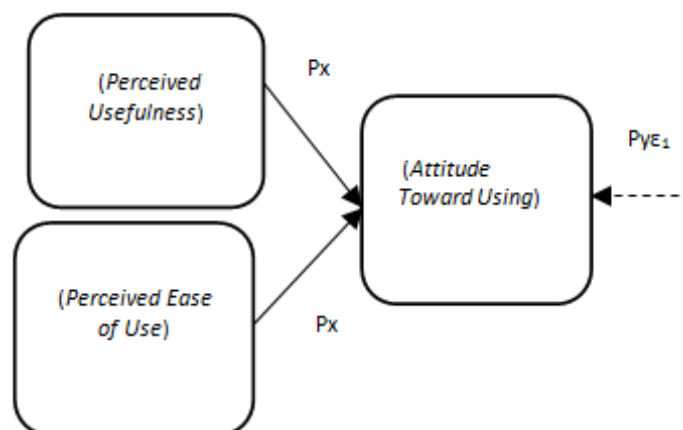
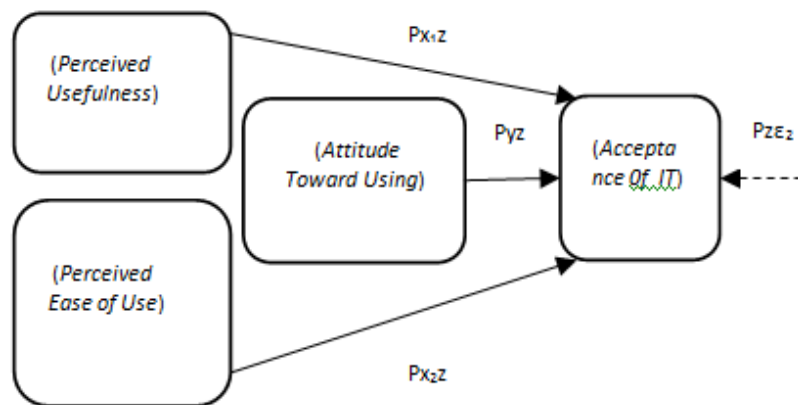


Figure 11 Substructure 1 to Y

2. Substructure 2 tests the influence of perceived usefulness ( $X_1$ ), perceived ease of use ( $X_2$ ) dan attitude toward using (Y) to actual system usage (Z).



**Figure 12** Substructure 2 to Z

From the description of the results of research conducted with the calculation of path analysis (path analysis) with the help of software SPSS 16 then it can be concluded the results based on the formulation of hypotheses that have been made among others:

1. The Assessment of perceived usefulness influences to attitude toward using

**Decision:**

Significance Value = 0.531 > 0.005, so  $H_0$  is accepted and  $H_a$  is rejected

2. Assessment of *perceived ease of use* influences to *attitude toward using*

**Decision:**

Significance Value = 0.000 < 0.005, so  $H_a$  is accepted and  $H_0$  is rejected

3. Assessment of perceived usefulness influences to acceptance IT

**Decision:**

Significance Value = 0.000 < 0.005, so  $H_a$  is accepted and  $H_0$  is rejected

4. Assessment of *perceived ease of use* influences to *acceptance IT*

**Decision:**

Significance Value = 0.000 < 0.005, so  $H_a$  is accepted and  $H_0$  is rejected

5. Assessment of *attitude toward using* influences to *acceptance IT*

**Decision:**

Significance Value = 0.000 < 0.005, so  $H_a$  is accepted and  $H_0$  is rejected

6. Assessment of *perceived usefulness*, *perceived ease of use* and *attitude toward using* simultaneously influence to *acceptance IT*.

**Decision:**

Significance Value = 0.000 < 0.005, so  $H_a$  is accepted and  $H_0$  is rejected

## 5. Conclusion

From the results of research that has been done on, the support system of credit feasibility decision making using fuzzy logic method Mamdani as well as hypothesis analysis, the Researcher can conclude some findings as follows:

1. Test results show that DSS with Fuzzy logic method Mamdani can produce high accuracy in this case is 98%.
2. The result of analysis of hypothesis test shows that partial test of perceived usefulness variable has no positive effect toward attitude toward using on the use of credit lending decision support system. While the perceived ease of use variable has a positive influence on attitude toward using on the use of decision support system creditworthiness and all the variables have a positive influence on the variable acceptance IT.
3. The results of hypothesis analysis showed that simultaneous testing where all the variables have a positive influence on IT acceptance variables.

Based on the description of the research and conclusions obtained, the Researcher can provide suggestions for further research to further conduct a deeper study of the following issues:

1. Further research can be added another criterion in determining the feasibility of the debtor, so there are many possibilities that can be considered to determine the output.
2. Expand the research indicators and add some variables such as behavioral intention to use variables or other powerful external variables, to measure system acceptance.
3. In this study only produce output "Rejected" and "Approved". For further research this can be developed by adding the "Considered" output as well as issuing suggestions that allow for acceptable credit

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