Classification of Open Unemployment Rate in Indonesia with Mamdani Fuzzy Inference System

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Abstract. Unemployment is a very common problem in developing countries such as Indonesia. One of the government’s efforts to overcome the problem is having skill training. However, the labor often faced difficulties in classifying unemployment in Indonesia. Therefore, the utilization of fuzzy logic is considered as an appropriate way to examine the state’s open unemployment rate by Mamdani method implementation. The input used in this case is the number of unemployment and labor force whereas the output of this system is the classification of open unemployment rate. Then the model output is compared to the classified data of the labor service and the result indicates that a matching percentage of 70.6 percent. It shows that the fuzzy model is able to determine the open unemployment rate in Indonesia.

1. Introduction

Unemployment is a key for macroeconomic variables and economic planning [1]. Indonesia as a developing country has complex problems which requires an appropriate policy to minimize its impact. One of the most challenging problems is the unemployment rate which influences the country’s economic rate of growth [2]. Unemployment may be concerned with individuals effort to look for job and their willingness to accept the market wage for a particular type of a job [3]. This problem arises because the economy does not reach the conditions of full employment so that a group of people who cannot work even though they want the job. The opportunity to work is low since companies, government organizations and other business entities have employed enough employees to produce goods and services. This resulted in a group of people who had to accept the fact that they could not work in the economic system.

Common reasons for unemployment is an ever-increasing labor force and growth in unequal employment opportunities. Furthermore, unemployment is also caused by the absence of employment and do not achieve the requirement to the terms set out. The labor forces who look for employment does not meet the qualifications requested by the business world because of low investment rates. Labor is a crucial factor in the economic development of each country [4]. The aim of increased job absorption is considered as a priority in building a country. Labor is a labor-age population. The population is classified as labor if the population has entered the labor age. The current labor-age in Indonesia is 15 to 64 years of age. It can be concluded that labor is one of the most important production factors in each country.
Indonesia has 34 provinces with different unemployment rates in each region. Solutions are proposed by the government to reduce the unemployment rate for one by providing skill and apprenticeship training[5]. However, it has not been to the maximum extent by Manpower in Indonesia since the difficulties are encountered in classifying the unemployment rate in Indonesia. Mamdani fuzzy inference system is one of the most famous applications of fuzzy logic and sets fuzzy theory [6-14]. These systems can be helpful to achieve classification tasks, offline process simulation, and diagnosis, online decision support tools and process control [15]. Therefore with fuzzy logic and the Mamdani method is proposed to deal with unemployment rate classification problem in Indonesia.

2. Research Methods
The research used data from Badan Pusat Statistik (Statistics Indonesia) in August 2018 [16]. The input used in this case is the number of unemployed and the labor force, while for the output from this system that is the classification of the open unemployment rate. Fuzzy sets theory is the base of materializing a fuzzy rule-based system that contains a rule base, a decision-making unit, and finally a defuzzification interface are shown in Figure 1. The function of each block is as follow [11,17-19].

a. A rule base containing a number of fuzzy if-then rules.
b. A database that defines the membership functions of the fuzzy sets used in the fuzzy rules.
c. A decision-making unit that performs the inference operation on the rules.
d. A fuzzification interface that transforms the crisp input to degrees of the match with linguistic values.
e. A defuzzification interface which transforms the fuzzy results of the interface into the crisp output.

![Research Flowchart](image)

**Figure 1.** Research Flowchart

This research used the data of labor force and number of open unemployment rates in 34 provinces in Indonesia which are listed in Table 1 below:

| No | The province       | Unemployment | Labor Force  | Open Unemployment Rate (%) |
|----|--------------------|--------------|--------------|-----------------------------|
| 1  | Aceh               | 63,985       | 898,523      | 7.12                        |
| 2  | North Sumatra      | 171,104      | 3,012,319    | 5.68                        |
| 3  | West Sumatra       | 67,815       | 1,048,676    | 6.47                        |
| 4  | Riau               | 82,787       | 1,058,323    | 7.82                        |
|   | Province     | Population (thousand) | Labour Force (thousand) | Unemployment Rate |
|---|--------------|-----------------------|-------------------------|-------------------|
| 5 | Jambi        | 31,020                | 664,203                 | 4.67              |
| 6 | Sumsel       | 67,540                | 1,591,886               | 4.24              |
| 7 | Bengkulu     | 16,666                | 392,970                 | 4.24              |
| 8 | Lampung      | 68,443                | 1,524,827               | 4.49              |
| 9 | Bangka Belitung | 9,993        | 256,996                 | 3.89              |
| 10 | Kep. Riau    | 18,888                | 340,655                 | 5.54              |
| 11 | DKI Jakarta  | 107,184               | 1,919,612               | 5.58              |
| 12 | West Java    | 656,956               | 7,548,649               | 8.70              |
| 13 | Central Java | 308,727               | 7,572,268               | 4.08              |
| 14 | DIY          | 32612                 | 981,475                 | 3.32              |
| 15 | East Java    | 324,111               | 8,699,117               | 3.73              |
| 16 | Banten       | 160,396               | 2,025,197               | 7.92              |
| 17 | Bali         | 9,478                 | 1,156,011               | 8.2               |
| 18 | NTB          | 32,058                | 967,601                 | 3.31              |
| 19 | NTT          | 31,749                | 1,084,437               | 2.93              |
| 20 | West Kalimantan | 41,751        | 931,997                 | 4.48              |
| 21 | Central Kalimantan | 24,372   | 475,758                 | 5.12              |
| 22 | South Kalimantan | 31,001         | 826,272                 | 3.75              |
| 23 | East Kalimantan | 41,438         | 569,751                 | 7.27              |
| 24 | North Kalimantan | 5,987          | 116,413                 | 5.14              |
| 25 | North Sulawesi | 35,867         | 414,060                 | 8.66              |
| 26 | Central Sulawesi | 22,955         | 571,426                 | 4.02              |
| 27 | South Sulawesi | 84,236         | 1,552,467               | 5.43              |
| 28 | Southeast Sulawesi | 19,900     | 502,025                 | 3.96              |
| 29 | Gorontalo    | 11,775                | 221,652                 | 5.31              |
| 30 | West Sulawesi | 9,588               | 251,889                 | 3.81              |
| 31 | Maluku       | 26,992                | 297,234                 | 9.08              |
| 32 | North Maluku | 13,103                | 202,649                 | 6.47              |
| 33 | West Papua   | 8,495                 | 161,224                 | 5.27              |
| 34 | Papua        | 21,750                | 767,658                 | 2.83              |

a. Fuzzification
The fuzzification process is an early stage where there is a crisp value in a fuzzy set [19]. In the other words turn a crisp value into a value ranging from 0 to 1 in the available fuzzy set. The set of variables used in this case is as follows:

1. Number of Unemployment: \{small, medium, large\}
2. Labor Force: \{small, medium, large\}
3. Open Unemployment Rate: \{low, medium, high\}

The membership functions of fuzzy sets in the variable of number of unemployment (in the hundreds of thousands) in each category are formulated as follows:
The graph of membership functions of fuzzy sets in the variable of number of unemployed is shown in Figure 2.

![Figure 2. Membership functions of fuzzy sets in the variable of number of unemployed](image)

The membership functions of fuzzy sets in the variable of labor force (in million units) are defined as follows.

\[
\mu_{LF_{small}}(x) = \begin{cases} 
1, & 0 \leq x \leq 1 \\
1,5-x & 1 \leq x \leq 1,5 \\
0, & x \geq 1,5
\end{cases}
\]

\[
\mu_{LF_{medium}}(x) = \begin{cases} 
0, & x \leq 1 \\
1, & 1 \leq x \leq 3 \\
1,5-x & 3 \leq x \leq 5 \\
1, & 5 \leq x \leq 6 \\
0, & x \geq 6
\end{cases}
\]

\[
\mu_{LF_{large}}(x) = \begin{cases} 
0, & x \leq 1 \\
1, & 1 \leq x \leq 3 \\
1,5-x & 3 \leq x \leq 5 \\
1, & 5 \leq x \leq 8 \\
0, & x \geq 8
\end{cases}
\]
The graph of membership functions of fuzzy sets in the variable of labor force is shown in Figure 3.

![Figure 3. Membership functions of fuzzy sets in the variable of labor force](image)

The membership functions of fuzzy sets in the variable of open unemployment rate (in units of millions) are defined as follows.

\[
\mu_{OUR_{low}}(x) = \begin{cases} 
1, & 0 \leq x \leq 2 \\
\frac{4-x}{2}, & 2 \leq x \leq 4 \\
0, & x \geq 4 
\end{cases}
\]

\[
\mu_{OUR_{medium}}(x) = \begin{cases} 
0, & x \leq 2 \\
\frac{x-2}{2}, & 2 \leq x \leq 4 \\
1, & 4 \leq x \leq 8 \\
\frac{8-x}{2}, & 6 \leq x \leq 8 \\
0, & x \geq 8 
\end{cases}
\]

\[
\mu_{OUR_{high}}(x) = \begin{cases} 
0, & x \leq 6 \\
\frac{x-6}{2}, & 6 \leq x \leq 8 \\
1, & x \geq 8 
\end{cases}
\]

The graph of membership function of fuzzy sets in the variable of open employment rate is shown in Figure 4.

![Figure 4. Membership functions of fuzzy sets in the variable of open unemployment rate](image)

b. Rule
Based on the number fuzzy sets on variable of number of unemployment and labor force, there are rules of Mamdani which should taken into account:
1. If (Number of Unemployment is small) and (Labor Force is medium), then (Open Unemployment Rate is medium) (1) 
2. If (Number of Unemployment is medium) and (Labor Force is small), then (Open Unemployment Rate is high) (1) 
3. If (Number of Unemployment is high) and (Labor Force is small), then (Open Unemployment Rate is high) (1) 
4. If (Number of Unemployment is high) and (Labor Force is medium), then (Open Unemployment Rate is high) (1) 
5. If (Number of Unemployment is medium) and (Labor Force is medium), then (Open Unemployment Rate is high) (1) 
6. If (Number of unemployment is small) and (Labor Force is high) then, (Open Unemployment Rate is medium) (1) 
7. If (Number of Unemployment is medium) and (Labor Force is high), then (Open Unemployment Rate is medium) (1) 
8. If (Number of Unemployment is small) and (Labor Force is small), then (Open Unemployment Rate is medium) (1) 
9. If (Number of Unemployment is high) and (Labor Force is high), then (Open Unemployment Rate is high) (1) 

c. Defuzzification
Defuzzification is a process to transform the fuzzy sets to real number. Center of Gravity (centroid) CoG is used as the Defuzzification [19]. This method aims to find the balance point of fuzzy solutions by calculating the average and output areas of fuzzy. This method is the most well-known one and widely used in previous studies.

3. Results and Discussion
Table 2 shows the results of defuzzification:

| No | The province       | Total Unemployment | Labor Force | Open Unemployment Rate (%) | Classification of Open Unemployment Rate from Manpower Office | Open Unemployment Rate Defuzzification | Conclusion fuzzy logic |
|----|--------------------|--------------------|-------------|-----------------------------|-------------------------------------------------------------|---------------------------------------|------------------------|
| 1  | Aceh               | 63,985             | 898,523     | 7.12                        | high                                                        | 5.00                                  | medium                 |
| 2  | Sumatra Utara      | 171,104            | 3,012,319   | 5.68                        | high                                                        | 8.2                                   | high                   |
| 3  | Sumatra Barat      | 67,815             | 1,048,676   | 6.47                        | high                                                        | 5.00                                  | medium                 |
| 4  | Riau               | 82,787             | 1,058,323   | 7.82                        | high                                                        | 5.00                                  | medium                 |
| 5  | Jambi              | 31,020             | 664,203     | 4.67                        | medium                                                      | 5.00                                  | medium                 |
| 6  | Sumsel             | 67,540             | 1,591,886   | 4.24                        | medium                                                      | 5.00                                  | medium                 |
| 7  | Bengkulu           | 16,666             | 392,970     | 4.24                        | medium                                                      | 5.00                                  | medium                 |
| 8  | Lampung            | 68,443             | 1,524,827   | 4.49                        | medium                                                      | 5.00                                  | medium                 |
| 9  | Bangka Belitung    | 9,993              | 256,996     | 3.89                        | medium                                                      | 5.00                                  | medium                 |
| 10 | Kep. Riau          | 18,888             | 340,655     | 5.54                        | medium                                                      | 5.00                                  | medium                 |
| 11 | DKI Jakarta        | 107,184            | 1,919,612   | 5.58                        | medium                                                      | 5.13                                  | medium                 |
The Table 2 shows the comparison results of the classification of open unemployment rate from manpower in Indonesia with classification from conclusion fuzzy logic. In order to find out the accuracy, a suitable amount of data is required. The amount of suitable data can be seen from the same amount of data between the classification from manpower and conclusion fuzzy logic. The percentage of accuracy of the fuzzy logic system with the actual conditions in the Labor Department as follow:

\[
\text{Accuracy} = \frac{\text{the amount of data being suitable}}{\text{the amount of all data}} \times 100% = \frac{24}{34} \times 100% = 70.6%.
\]

This percentage match proves that the fuzzy logic method with the Mamdani method which aims to determine the classification of open unemployment rate in 34 provinces in Indonesia is able to be used as an appropriate support tool [20]. It indicates that classification of open unemployment rate in Indonesia comes the conclusion fuzzy logic. The province in Indonesia that has high classification is

| No. | Province          | Population | Unemployment Rate | Level | Classification | Open Unemployment Rate |
|-----|-------------------|------------|-------------------|-------|----------------|------------------------|
| 12  | West Java         | 656,956    | 7,548,649         | 8.70  | high           | 8.38                   |
| 13  | Central Java      | 308,727    | 7,572,268         | 4.08  | medium         | 5.00                   |
| 14  | DIY               | 326,12     | 981,475           | 3.32  | medium         | 5.00                   |
| 15  | East Java         | 324,111    | 8,699,117         | 3.73  | medium         | 5.00                   |
| 16  | Banten            | 160,396    | 2,025,197         | 7.92  | high           | 8.17                   |
| 17  | Bali              | 9,478      | 1,156,011         | 0.82  | low            | 5.00                   |
| 18  | NTB               | 32,058     | 967,601           | 3.32  | medium         | 5.00                   |
| 19  | NTT               | 31,749     | 1,084,437         | 2.93  | low            | 5.00                   |
| 20  | West Kalimantan   | 41,751     | 931,997           | 4.48  | medium         | 5.00                   |
| 21  | Central Kalimantan| 24,372     | 475,758           | 5.12  | medium         | 5.00                   |
| 22  | South Kalimantan  | 31,001     | 826,272           | 3.75  | medium         | 5.00                   |
| 23  | East Kalimantan   | 41,438     | 569,751           | 7.27  | high           | 5.00                   |
| 24  | North Kalimantan  | 5,987      | 116,413           | 5.14  | medium         | 5.00                   |
| 25  | North Sulawesi    | 35,867     | 414,060           | 8.66  | high           | 5.00                   |
| 26  | Central Sulawesi  | 22,955     | 571,426           | 4.02  | medium         | 5.00                   |
| 27  | South Sulawesi    | 84,236     | 1,552,467         | 5.43  | medium         | 5.00                   |
| 28  | Southeast Sulawesi| 19,900     | 502,025           | 3.96  | medium         | 5.00                   |
| 29  | Gorontalo         | 11,775     | 221,652           | 5.31  | medium         | 5.00                   |
| 30  | West Sulawesi     | 9,588      | 251,889           | 3.81  | medium         | 5.00                   |
| 31  | Maluku            | 26,992     | 297,234           | 9.08  | high           | 5.00                   |
| 32  | North Maluku      | 13,103     | 202,649           | 6.47  | high           | 5.00                   |
| 33  | West Papua        | 8,495      | 161,224           | 5.27  | medium         | 5.00                   |
| 34  | Papua             | 21,750     | 767,658           | 2.83  | low            | 5.00                   |
Sumatra, West Java, and Banten. In addition, the other 31 provinces had medium classification and the province had low classification did not exist.

4. Conclusions
The Mamdani model on fuzzy logic can be used to determine the classification of open unemployment rate in Indonesia with input comes the number of unemployed and labor force. The model application in the research test data produced a 70.6 percent match so that it could be used to determine the classification of open unemployment rate in Indonesia.

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