Selection of supplier for the evaluation of procurement of special chemical using entropy method and topsis in xyz company

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Abstract. In the process of procuring special materials, the company has more than one supplier for each item of goods, at XYZ companies selecting suppliers through process evaluation. In the evaluation process the supplier is chosen only based on the lowest price offered by the supplier, these criteria have not been able to ensure the selected supplier can meet other criteria such as quality, transportation system and so on. This study aims to determine whether the criteria that have the highest weight value in the selection of suppliers and to find out the best supplier in the purchase of special materials XYZ companies. In this study, the Entropy and TOPSIS methods are used to analyse the data. Entropy method is used to calculate the weight of each criterion and alternatives, while the TOPSIS method is used to rank suppliers. The results showed that the criterion that had the highest weighting value in the selection of special material suppliers in the special material purchasing section of XYZ company was the criterion C3 and C12 with positive ideal solution value 0.0380 and 0.0389. Whereas the best supplier for PT XYZ's special material purchasing department is supplier E with a preference value of 0.5517.

1. Introduction
During this time the Special Material Purchase section of XYZ Company utilizes supplier companies to meet the needs of special goods / materials. Special materials that must be fulfilled are chemicals. This chemical is used in the laboratory for the production testing process. PT. XYZ selects suppliers through a tender process. This causes the supplier selection process through the tender process to not run as expected by the company. This discrepancy occurs because the selection of suppliers is only based on one type of criteria. This study wants to help XYZ companies determine the criteria for selecting the right supplier so that suppliers are selected through a tender evaluation process in accordance with company expectations. In the tender process the supplier is chosen only based on the lowest price offered by the supplier. The lowest price criteria itself is not necessarily able to ensure that the selected supplier can meet other criteria, such as quality, transportation systems, and so on. The company should also consider other criteria. Therefore, companies need to assess suppliers carefully and continuously because supplier assessments require a variety of criteria not just one criterion. Recently, the special materials are purchased from five suppliers. The supplier is A company (A), B company (B), C company (C), D company (D), and E company (E).

In general, companies have more than one supplier for each item of goods. The selection of the right supplier can guarantee the availability of goods needed by the company. The selection of suppliers that are based on low price quotes is no longer efficient to get maximum supply chain performance, companies must pay attention to other relevant criteria to achieve company goals. In terms of finding and choosing suppliers, it is necessary to determine the people who are interested in making the decision. Supplier selection is a multi-criteria problem which includes qualitative and
quantitative factors. If several criteria are considered in a decision making process problem then the problem is known as Multi Criteria Decision Making (MCDM)[1,2,11–13,3–10]. Therefore we need a method that can include both of them in the measurement. In this case the method used for supplier selection is the TOPSIS (Technique For Order Preference By Similarity To Ideal Solution) Method[1,2,13,4–10,12].

TOPSIS was first introduced by Yoon and Hwang in 1981 to be used as a method for solving multi-criteria problems[1,2,4,5,10]. TOPSIS provides a solution of a number of possible alternatives by comparing each alternative with the best alternative and the worst alternative that exists among alternative problems[4,5]. Apply the TOPSIS method to select suppliers of cement, sand, iron, foundation stone and wood. And obtained 13 criteria in the selection of suppliers, namely the appropriateness of prices with the quality of goods produced (C1), the ability to provide discounts (discounts) on orders in a certain amount (C2), the suitability of goods with the specifications set (C3), the supply of goods without defects (C4), the ability to provide consistent quality (C5), the ability to deliver goods according to the agreed date (C6), the ability to handle the transportation system (C7), the accuracy and suitability of the quantities in the shipment (C8), the suitability of the contents of the package (C9), the ease of contact (C10), the ability to provide information clearly and easily to understand (11), the speed in responding to customer requests (C12), and responsive in resolving customer complaints (C13)[6,8,14]. Prior to ranking, all the criteria specified are weighted. Weighting is done using the entropy method[1,3,9,12]. And TOPSIS is used to rank the alternatives supplier.

2. Methodology

The stage of the research begins by making a research questionnaire based on literature studies and interviews with experts. Each question in the questionnaire was designed by setting one question for each criterion. Besides that, in the questionnaire also assessments were made for each supplier. The measurement scale used on the questionnaire is a Likert scale with a range from 1-10. The experts used as respondents in this study were the workers in the XYZ company specialized material purchasing division. The number of respondents consists of six people, each of whom has work experience in the field of purchasing and procurement.

After the questionnaire was successfully designed, it was then given to all respondents to be filled. The completed questionnaire was then processed using the entropy method to weight each criterion and the TOPSIS method to rank each alternative supplier. After that it is closed with conclusions and suggestions. The supplier selection model can be summarized in Figure 1.
2.1. Supplier selection
Supplier selection process is very important for the company because it will have an impact on the company's financial condition in the long run[12]. Supplier selection is the most frequent decision making problem. Quantitative and qualitative factors are needed to identify the right supplier according to the company's requirements and budget criteria. Raw materials provided by suppliers will have an impact on the products produced by the company. If the raw material supplied by the supplier is of high quality, the products produced by the company will be in accordance with customer requirements. Several approaches can be used to solve the problem of supplier selection decision making. However, in this study the entropy method is used for weighting criteria and TOPSIS to rank alternative suppliers to be chosen by the company. The supplier selection evaluation process is summarized in Figure 2.

2.2. Entropy
The entropy weighting method was first introduced by Shannon (2001)[12]. The term entropy is known in the concept of thermodynamics, which was later adopted for the world of information systems. Every sign of uncertainty in the communication process is called information entropy. If the level of information uncertainty is lower the higher the weighting value. Weight is the relative importance of the evaluation of a certain criterion[9]. The assessment of criteria weights is determined from the opinion of the decision maker.
If there are multiple decision makers, the assessment of criteria weights becomes more difficult. This is because each decision maker has a different view in assessing a criterion. Other than that, entropy weighting does not require criteria to have the same unit or range. Based on Maisari et al [9], the following are the stages of the entropy method in weighting a criterion.

- **Evaluation criteria**, each respondent provides an assessment for each criterion based on the level of importance in selecting suppliers.
- **Normalizing the initial data**, subtract the criterion value from the preferences of the respondents with the value of the maximum criteria importance level range. Give a notation $k_{ij}$ for the subtraction result, $i$ is the number of respondents and $j$ is the number of criteria.
- **Determine criteria matrix value**. Denoted by $a_{ij}$
  \[
  a_{ij} = \frac{k_{ij}}{\sum_{i=1}^{m} \sum_{j=1}^{n} k_{ij}} \tag{1}
  \]
  $a_{ij}$ = criteria matrix value
  $k_{ij}$ = initial data (normalize criteria value)
  $i$ = number of respondent
  $j$ = number of criteria
- **Calculation of the entropy value for each criterion**. Denoted by $E_j$
  \[
  E_j = \left[\frac{-1}{\ln m}\right] \sum_{i=1}^{m} \left[a_{ij} \ln a_{ij}\right] \tag{2}
  \]
- **Dispersion calculation for each criterion**. Denoted by $D_j$
  \[
  D_j = 1 - E_j \tag{3}
  \]
• Normalization of dispersion value. Denoted by \( w_j \)
\[
w_j = \frac{d_j}{\sum d_j}
\]

2.3. TOPSIS
TOPSIS is a practical and simple decision-making method that uses performance measurements in a simple mathematical form[9]. The advantage of this method is that the optimal solution is obtained from the comparison between the best alternative and the worst alternative, thus narrowing the possibility of subjective judgments[9,12]. The following are the calculation steps using the TOPSIS method[9].

- Form a decision matrix. Denoted by \( x_{ij} \)
- Calculate the normalized decision matrix
\[
r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}
\]

\( r_{ij} \) = normalized decision matrix
\( x_{ij} \) = decision matrix
\( i \) = number of criteria
\( j \) = number of alternative (supplier)
- Calculating a weighted normalized decision matrix, denoted by \( y_{ij} \)
\[
y_{ij} = w_i r_{ij}
\]
- Determine the positive ideal solution matrix and the negative ideal solution matrix
  - Positive ideal solution matrix is denoted by \( A^+ \)
  \[
  A^+ = (y^+_1, y^+_2, ..., y^+_n)
  \]
  \[
  y^+_i = \max(y_{1i}, y_{12}, ..., y_{6j})
  \]
  - Negative ideal solution matrix is denoted by \( A^- \)
  \[
  A^- = (y^-_1, y^-_2, ..., y^-_n)
  \]
  \[
  y^-_i = \min(y_{1i}, y_{12}, ..., y_{6j})
  \]
  \( y^+_i \) = the maximum value of the weighted normalized decision matrix
  \( y^-_i \) = the minimum value of the weighted normalized decision matrix
- Calculate alternative distances for each ideal solution
  - Alternative distances for ideal positive solutions denoted by \( D_j^+ \)
  \[
  D_j^+ = \sqrt{\sum_{i=1}^{n} (y^+_i - y_{ij})^2}
  \]
  - Alternative distances for ideal negative solutions denoted by \( D_j^- \)
  \[
  D_j^- = \sqrt{\sum_{i=1}^{n} (y^-_i - y_{ij})^2}
  \]
- Calculate the preference value of each alternative solution denoted by \( V_j \)
\[
V_j = \frac{D_j^-}{D_j^+ + D_j^-}
\]
- Ranking alternative solution preference value. Ranking is done by sorting the largest \( V_j \) value to the smallest value. \( V_j \) with the greatest value is the optimal solution or the best supplier chosen by the company.

3. Result
3.1. Numerical example of entropy method
3.1.1. Initial data
The questionnaire distributed to respondents was then summarized in a table or matrix. The table or matrix is the result of an assessment of six respondents for the available alternatives. The following
matrix is preliminary data for alternative suppliers A. Initial data for other suppliers is shown in the appendix.

### Table 1. Initial data questionnaire for alternative A

| Respondent | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 |
|------------|----|----|----|----|----|----|----|----|----|------|-----|------|-----|
| 1          | 7  | 8  | 7  | 7  | 8   | 8  | 8  | 8  | 8  | 7    | 7   | 7    | 8   |
| 2          | 8  | 5  | 7  | 6  | 8   | 7  | 7  | 7  | 8  | 9    | 6   | 6    | 6   |
| 3          | 7  | 7  | 7  | 7  | 9   | 7  | 7  | 7  | 8  | 7    | 7   | 7    | 7   |
| 4          | 8  | 8  | 8  | 7  | 8   | 8  | 9  | 8  | 8  | 7    | 8   | 7    | 7   |
| 5          | 7  | 7  | 8  | 7  | 8   | 7  | 7  | 6  | 6  | 7    | 7   | 7    | 7   |
| 6          | 7  | 7  | 7  | 7  | 9   | 7  | 7  | 7  | 7  | 7    | 7   | 7    | 7   |

### 3.1.2. Normalized initial data

The maximum value of the Likert scale used on the questionnaire is 10. In table 1, it can be seen that the respondent's value 1 for criterion 1 is 7 so the initial normalized value for \( C_{11} \) is -3.

\[
C_{11} \approx \frac{7 - 10}{209} = -0.0144
\]

Based on the initial data normalization calculation, the initial data is normalized, which then forms a normalized initial data matrix. Table 2 below provides an overview of the initial normalized data matrix for Alternative A.

### Table 2. Initial normalized data matrix for alternative A

| Respondent (R) | Criteria | \( \sum \) |
|----------------|----------|---------|
|                | C1       | C2      | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 |       |
| 1              | -3       | -2      | -3 | -3 | -2 | -2 | -2 | -2 | -2 | -3  | -3  | -3  | -2   | -32  |
| 2              | -2       | -5      | -3 | -4 | -2 | -3 | -3 | -3 | -2 | -1  | -4  | -4  | -4   | -40  |
| 3              | -3       | -3      | -3 | -1 | -3 | -3 | -3 | -2 | -2 | -2  | -3  | -3  | -3   | -36  |
| 4              | -2       | -2      | -2 | -2 | -2 | -2 | -2 | -1 | -2 | -2  | -2  | -2  | -3   | -27  |
| 5              | -3       | -3      | -3 | -2 | -2 | -2 | -2 | -1 | -3 | -3  | -3  | -3  | -3   | -37  |
| 6              | -3       | -3      | -3 | -1 | -3 | -3 | -3 | -3 | -3 | -3  | -3  | -3  | -3   | -37  |
| \( \sum \)     | -16      | -18     | -16 | -18 | -11 | -15 | -16 | -16 | -14 | -18 | -17 | -18 | 209  |

### 3.1.3. Criteria value

The formula for the criteria value is obtained from equation 1. An example of calculating the criteria value for criterion 1 by respondent 1 is as follows.

\[
a_{11} \approx \frac{-3}{-209} = 0.0144
\]

\[
a_{12} \approx \frac{-2}{-209} = 0.0096
\]

\[
\cdots
\]

\[
a_{613} \approx \frac{-3}{-209} = 0.0144
\]

Table 3 below provides an overview of the criteria value matrix for all respondents.
Table 3. The criteria value matrix for alternative A

| Criteria value | C1       | C2       | C3       | C4       | C5       | C6       | C7       | C8       | C9       | C10      | C11      | C12      | C13      |
|----------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| R              | a_{1n}  | a_{2n}  | a_{3n}  | a_{4n}  | a_{5n}  | a_{6n}  | a_{7n}  | a_{8n}  | a_{9n}  | a_{10n} | a_{11n} | a_{12n} | a_{13n} |
| 1              | 0.0144  | 0.0096  | 0.0144  | 0.0144  | 0.0096  | 0.0096  | 0.0096  | 0.0096  | 0.0096  | 0.0144  | 0.0144  | 0.0144  | 0.0096  |
| 2              | 0.0096  | 0.0239  | 0.0144  | 0.0191  | 0.0096  | 0.0144  | 0.0144  | 0.0144  | 0.0096  | 0.0048  | 0.0191  | 0.0191  | 0.0191  |
| 3              | 0.0144  | 0.0144  | 0.0144  | 0.0144  | 0.0048  | 0.0144  | 0.0144  | 0.0144  | 0.0144  | 0.0096  | 0.0144  | 0.0144  | 0.0144  |
| 4              | 0.0096  | 0.0096  | 0.0096  | 0.0144  | 0.0096  | 0.0096  | 0.0096  | 0.0096  | 0.0096  | 0.0096  | 0.0096  | 0.0096  | 0.0096  |
| 5              | 0.0144  | 0.0144  | 0.0144  | 0.0144  | 0.0096  | 0.0144  | 0.0144  | 0.0144  | 0.0191  | 0.0191  | 0.0144  | 0.0144  | 0.0096  |
| 6              | 0.0144  | 0.0144  | 0.0144  | 0.0144  | 0.0048  | 0.0144  | 0.0144  | 0.0144  | 0.0144  | 0.0144  | 0.0144  | 0.0144  | 0.0144  |

3.1.4. Entropy value

Equation 2 is used to calculate the entropy value for each criterion. The following is a calculation of the entropy value for alternative A. The number of respondents in this study is six people so that the value of \( m \) is 6. \( \ln(6) = 1.7918 \) and \( \ln(0.0144) = -4.2404; \ln(0.0096) = -4.6460 \)

\[
E_1 = \frac{-1}{\ln(6)} \sum_{i=1}^{6} \left[ (-0.0611) + (-0.0446) + (-0.0611) + (-0.0446) + (-0.0611) + (-0.0611) \right] \\
E_2 = \frac{-1}{\ln(6)} \sum_{i=1}^{6} \left[ (-0.0446) + (-0.0892) + (-0.0611) + (-0.0446) + (-0.0611) + (-0.0611) \right] + (-0.0611) \approx 0.2019
\]

\[E_{13}\]

Table 4 below is a summary of the entropy value for all criteria of alternative A.

Table 4. Entropy value matrix for alternative A

| Criteria | Entropy value \( (E_i) \) |
|----------|--------------------------|
| 1        | 0.1862                   |
| 2        | 0.2019                   |
| 3        | 0.1862                   |
| 4        | 0.2035                   |
| 5        | 0.1373                   |
| 6        | 0.1770                   |
| 7        | 0.1862                   |
| 8        | 0.1837                   |
| 9        | 0.1851                   |
| 10       | 0.1664                   |
| 11       | 0.2035                   |
| 12       | 0.1943                   |
| 13       | 0.2035                   |

3.1.5. Dispersion value

Equation 3 is used to calculate the dispersion value for each criterion. The following is a calculation of the dispersion value for alternative A.
3.1.6. Normalized dispersion value

Equation 4 is used to calculate the normalized dispersion value or criteria weights for each criterion. The following is a calculation of the normalized dispersion value for alternative A.

\[ w_1 = \frac{D_1}{\sum D_j} \approx \frac{0.8138}{10.5852} \approx 0.0769 \]
\[ w_2 = \frac{D_2}{\sum D_j} \approx \frac{0.7981}{10.5852} \approx 0.0754 \]
\[ \vdots \]
\[ w_{13} = \frac{D_{13}}{\sum D_j} \approx \frac{0.7965}{10.5852} \approx 0.0752 \]

Table 6 below is a summary of the entropy value for all criteria of alternative A.

| Criteria | Weights |
|----------|---------|
| 1        | 0.0769  |
| 2        | 0.0754  |
| 3        | 0.0769  |
| 4        | 0.0752  |
| 5        | 0.0815  |
| 6        | 0.0778  |
| 7        | 0.0769  |
| 8        | 0.0771  |
| 9        | 0.0770  |
| 10       | 0.0788  |
| 11       | 0.0752  |
| 12       | 0.0761  |
| 13       | 0.0752  |
3.2. Numerical example of TOPSIS

3.2.1. Decision matrix

The decision matrix is a matrix with the order $m \times n$, where $m$ is the number of alternatives (suppliers) and $n$ is the number of criteria. The decision matrix value is taken from the normalized dispersion value or the result of weighting criteria for each alternative (supplier). Because suppliers number five, $m$ equals five and criteria number 13, then $n$ equals 13. Table 7 shows the decision matrix for all alternatives and criteria that have been determined using the entropy method.

Table 7. Decision matrix for all alternatives

| Criteria | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 |
|----------|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|
|          | $w_1$ | $w_2$ | $w_3$ | $w_4$ | $w_5$ | $w_6$ | $w_7$ | $w_8$ | $w_9$ | $w_{10}$ | $w_{11}$ | $w_{12}$ | $w_{13}$ |
| A        | 0.0777 | 0.0756 | 0.077 | 0.0748 | 0.0762 | 0.0785 | 0.0777 | 0.0777 | 0.0756 | 0.0794 | 0.0763 | 0.07762 | 0.0771 |
| B        | 0.0785 | 0.0778 | 0.0769 | 0.0754 | 0.0769 | 0.0786 | 0.0769 | 0.0771 | 0.0786 | 0.0761 | 0.0747 | 0.0740 |
| C        | 0.0785 | 0.0769 | 0.0794 | 0.0785 | 0.076 | 0.0751 | 0.0777 | 0.0759 | 0.0803 | 0.0763 | 0.0752 | 0.0736 | 0.0768 |
| D        | 0.0767 | 0.0715 | 0.0771 | 0.0771 | 0.078 | 0.0787 | 0.0771 | 0.0772 | 0.079 | 0.0771 | 0.0767 | 0.0777 |
| E        | 0.0768 | 0.08 | 0.0816 | 0.0786 | 0.0724 | 0.0769 | 0.0768 | 0.0724 | 0.0731 | 0.0785 | 0.0761 | 0.0816 | 0.0761 |

3.2.2. Normalized decision matrix

Equation 5 is used to calculate the normalized decision matrix for all alternatives and criteria. The following is a normalized matrix calculation for alternative A and criterion 1, followed by the same method until alternative E and criterion 13. Table 8 summarizes the results of the normalized decision matrix for all alternatives and criteria.

\[
r_{A1} = \frac{0.0777}{\sqrt{(0.0777)^2+(0.0785)^2+(0.0754)^2+(0.0769)^2+(0.0786)^2}} \approx 0.4475
\]

\[
r_{E13} = \frac{0.0761}{\sqrt{(0.0771)^2+(0.074)^2+(0.0768)^2+(0.0777)^2+(0.0761)^2}} \approx 0.4457
\]

Table 8. Normalized decision matrix for all alternatives

| Normalized decision matrix ($r$) | $r_1$ | $r_2$ | $r_3$ | $r_4$ | $r_5$ | $r_6$ | $r_7$ | $r_8$ | $r_9$ | $r_{10}$ | $r_{11}$ | $r_{12}$ | $r_{13}$ |
|----------------------------------|------|------|------|------|------|------|------|------|------|---------|---------|---------|---------|
| A                               | 0.4475 | 0.4425 | 0.4391 | 0.4350 | 0.4488 | 0.4534 | 0.4481 | 0.4571 | 0.4408 | 0.4531 | 0.4480 | 0.4448 | 0.4516 |
| B                               | 0.4521 | 0.4553 | 0.4385 | 0.4385 | 0.4530 | 0.4540 | 0.4527 | 0.4524 | 0.4496 | 0.4485 | 0.4468 | 0.4361 | 0.4334 |
| C                               | 0.4521 | 0.4501 | 0.4528 | 0.4565 | 0.4477 | 0.4338 | 0.4481 | 0.4465 | 0.4682 | 0.4354 | 0.4416 | 0.4296 | 0.4498 |
| D                               | 0.4418 | 0.4185 | 0.4397 | 0.4484 | 0.4594 | 0.4505 | 0.4441 | 0.4535 | 0.4502 | 0.4508 | 0.4527 | 0.4477 | 0.4551 |
| E                               | 0.4424 | 0.4682 | 0.4653 | 0.4571 | 0.4265 | 0.4441 | 0.4429 | 0.4259 | 0.4262 | 0.4480 | 0.4468 | 0.4763 | 0.4457 |

3.2.3. Weighted normalized decision matrix

Equation 6 is used to determine the weighted normalized decision matrix for all alternatives and criteria. The following is a calculation for alternative weighted normalized decision A and criterion 1. Table 9 summarizes all the weighted normalized decision calculation values for all alternatives and criteria.

\[
y_{A1} \approx 0.0777 \times 0.4475 = 0.0348
\]

\[
y_{A2} \approx 0.0756 \times 0.4425 = 0.0334
\]

\[
y_{E13} \approx 0.0761 \times 0.4457 = 0.0339
\]
Table 9. Weighted normalized decision matrix for all alternatives and criteria

|     | Y1  | Y2  | Y3  | Y4  | Y5  | Y6  | Y7  | Y8  | Y9  | Y10 | Y11 | Y12 | Y13 |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| A   | 0.0348 | 0.0335 | 0.0338 | 0.0325 | 0.0342 | 0.0356 | 0.0348 | 0.0355 | 0.0333 | 0.0360 | 0.0342 | 0.0339 | 0.0348 |
| B   | 0.0355 | 0.0354 | 0.0337 | 0.0331 | 0.0348 | 0.0357 | 0.0355 | 0.0348 | 0.0347 | 0.0353 | 0.0340 | 0.0326 | 0.0321 |
| C   | 0.0355 | 0.0346 | 0.0360 | 0.0358 | 0.0340 | 0.0326 | 0.0348 | 0.0339 | 0.0376 | 0.0332 | 0.0332 | 0.0316 | 0.0345 |
| D   | 0.0339 | 0.0299 | 0.0339 | 0.0346 | 0.0358 | 0.0351 | 0.0342 | 0.0350 | 0.0348 | 0.0356 | 0.0349 | 0.0343 | 0.0354 |
| E   | 0.0340 | 0.0375 | 0.0380 | 0.0359 | 0.0309 | 0.0342 | 0.0340 | 0.0308 | 0.0312 | 0.0352 | 0.0340 | 0.0389 | 0.0339 |

3.2.4. Positive ideal solution matrix

Equation 8 is used to determine the value of a positive ideal solution for all criteria. The following is calculation of a positive ideal solution for alternative A with criterion 1 and criterion 2. The calculation is carried out to the end i.e. for alternative E criterion 13. The following table 10 summarizes the value of a positive ideal solution for all criteria.

- \( y_1^+ = \max\{0.0348; 0.0355; 0.0355; 0.0339; 0.0340\} \approx 0.0355 \)
- \( y_2^+ = \max\{0.0335; 0.0354; 0.0346; 0.0299; 0.0375\} \approx 0.0375 \)
- \( y_{13}^+ = \max\{0.0348; 0.0321; 0.0345; 0.0354; 0.0339\} \approx 0.0354 \)

Table 10. Positive ideal solution for all criteria

|     | Y1+ | Y2+ | Y3+ | Y4+ | Y5+ | Y6+ | Y7+ | Y8+ | Y9+ | Y10+ | Y11+ | Y12+ | Y13+ |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     | 0.0355 | 0.0375 | 0.0380 | 0.0359 | 0.0358 | 0.0357 | 0.0355 | 0.0355 | 0.0376 | 0.0360 | 0.0349 | 0.0389 | 0.0354 |

3.2.5. Negative ideal solution matrix

Equation 10 is used to determine the value of a negative ideal solution for all criteria. The following is calculation of a negative ideal solution for criterion 1 and criterion 2. The calculation is carried out to the end i.e. for alternative E criterion 13. The following table 11 summarizes the value of a negative ideal solution for all criteria.

- \( y_1^- \approx \min\{0.0348; 0.0355; 0.0355; 0.0339; 0.0340\} = 0.0340 \)
- \( y_2^- \approx \min\{0.0335; 0.0354; 0.0346; 0.0299; 0.0375\} = 0.0299 \)
- \( y_{13}^- \approx \min\{0.0348; 0.0321; 0.0345; 0.0354; 0.0339\} = 0.0321 \)

Table 11. Negative ideal solution for all criteria

|     | Y1- | Y2- | Y3- | Y4- | Y5- | Y6- | Y7- | Y8- | Y9- | Y10- | Y11- | Y12- | Y13- |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|     | 0.0339 | 0.0299 | 0.0337 | 0.0325 | 0.0309 | 0.0326 | 0.0340 | 0.0308 | 0.0312 | 0.0332 | 0.0332 | 0.0316 | 0.0321 |

3.2.6. Distances for positive ideal solution matrix

Equation 11 is used to determine the value of a distance for positive ideal solution for all alternatives. The following is a calculation for the distance for a positive ideal solution for alternative A. Table 12 below summarizes the values for the distance for a positive ideal solution for all alternatives.

\[ \begin{align*}
D_A^+ & \approx \sqrt{(0.0355-0.0348)^2+(0.0375-0.0335)^2+(0.038-0.0338)^2+(0.0359-0.0325)^2+(0.0358-0.0342)^2 + \\
& (0.0357-0.0356)^2+(0.0355-0.0348)^2+(0.0355-0.0355)^2+(0.0376-0.0333)^2+(0.036-0.036)^2 + \\
& (0.0349-0.0342)^2+(0.0389-0.0339)^2+(0.0354-0.0348)^2}
\end{align*} \]

\[ = 0.00961 \]
Table 12. Distances for positive ideal solution for all alternatives

|       | D_A^+ | D_B^+ | D_C^+ | D_D^+ | D_E^+ |
|-------|-------|-------|-------|-------|-------|
| 012046| 0,00961 | 0,00961 | 0,00959 | 0,01044 | 0,00992 |

3.2.7. Distances for negative ideal solution
Equation 12 is used to determine the value of a distance for negative ideal solution for all alternatives. The following is a calculation for the distance for a negative ideal solution for alternative A. Table 13 below summarizes the values for the distance for a negative ideal solution for all alternatives.

- \( D_A^- \approx \sqrt{(0,0339-0,0348)^2 + (0,0299-0,0335)^2 + (0,0337-0,0338)^2 + (0,0325-0,0325)^2 + (0,0309-0,0342)^2} + (0,0326-0,0356)^2 + (0,034-0,0348)^2 + (0,0308-0,0355)^2 + (0,0332-0,036)^2 + (0,0332-0,0342)^2 + (0,0316-0,0339)^2 + (0,0312-0,0348)^2 \) = 0,00905

Table 13. Distances for negative ideal solution for all alternatives

|       | D_A^- | D_B^- | D_C^- | D_D^- | D_E^- |
|-------|-------|-------|-------|-------|-------|
| 012046| 0,00905 | 0,00971 | 0,01039 | 0,0096 | 0,01221 |

3.2.8. Preference value matrix
Equation 13 is used to determine the value of preference matrix for all alternatives. The following is a calculation for the value of preference matrix for alternative A. Table 14 below summarizes the values for the value of preference for all alternatives.

- \( V_A \approx \frac{D_A^+}{D_A^+ + D_A^-} \approx \frac{0,00961}{0,00961 + 0,00905} = 0,4849 \)
- \( V_B \)
- \( V_E \)

Table 14. Preference value matrix

|       | V_A  | V_B | V_C | V_D | V_E |
|-------|------|-----|-----|-----|-----|
| 012046| 0,4849 | 0,5027 | 0,52 | 0,4791 | 0,5517 |

4. Conclusion
Supplier selection must be evaluated based on several criteria, not limited to just one criterion. Entropy and TOPSIS methods are able to provide optimal solutions to supplier selection problems in the procurement of specialty chemicals in XYZ companies. Based on the evaluation results of supplier selection criteria using the entropy method and TOPSIS it can be concluded that the C3 and C12 criteria are the most important criteria. These criteria are the conformity of the goods with the specified specifications and the speed criteria in responding to customer requests. While based on ranking using the TOPSIS method, five suppliers were selected as suppliers of specialty chemicals for XYZ companies. The suitability of goods with the specifications set (C3) and the speed in responding to customer requests (C12) criterion values are obtained from the value of a positive ideal solution matrix with values of 0.0380 and 0.0389. While the selection of suppliers E, is based on the final preference value of 0.5517. Therefore, so that the process of evaluating supplier selection through tenders is in line with company expectations, the company must consider criteria the suitability of
goods with the specifications set (C3) and the speed in responding to customer requests (C12) for selecting suppliers.

In this study the entropy method is not able to provide an objective assessment to provide weight values for the overall criteria. However, these deficiencies can be covered by the TOPSIS method. Therefore, it is better that in the future the study includes fuzzy numbers to eliminate deficiencies that still exist in the entropy method.

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