# EVALUATION MATURITY INDEX AND RISK MANAGEMENT FOR IT GOVERNANCE USING FUZZY AHP AND FUZZY TOPSIS
## (CASE STUDY BANK XYZ)

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**Abstract—Risk management maturity index should be measured to determine whether the application of risk management within the organization succeed or not. Assessment of risk management maturity index is very important because it allows the identification of strengths and weaknesses of the organization that can be used to improve corporate governance and organization risk managementt. Many measurement methods that have been used, but when but when we get a less good data, this will cause some problems. Existing data are sometimes inadequate for problems in real life. For that we need a new model to perform a measurement. In this study using fuzzy logic models in making a decision of structured preference maker. Fuzzy theory helps in measuring the concept of uncertainty related to human which is subjective. Two applications of fuzzy namely Fuzzy AHP is used to determine the weight of the specified criteria and Fuzzy TOPSIS to rank of selected alternatives. This study uses a case study of Bank XYZ as an object of research. The results of this research to get Skills and Expertise (SE) : 0.041641. For the calculation of risk management SW/HW (Slow Connection) : 0.87410948**

**Keywords— Maturity Index, Risk Managament, IT Governance, COBIT, FAHP, FTOPSIS**

## I. INTRODUCTION

Information Systems (IS) develop operational and managerial activities in internal control, increasing the guarantee of CG mainly related to the measurement requirement of confidentiality, integrity, availability and compliance. These aspects are present in different evaluation frameworks related to information security processes [5]; [14] and [4]. This paper focuses specifically on the analysis of the strategic alignment focal area, using the COBIT framework and seeking to reduce the problems between business and IT.

The lack of a strategic alignment between IT and business causes competitiveness losses as established by [3]; [10]; [15] and also a limited improvement in strategic information systems (SIS) planning [7] that supports the achievement of the organizational objectives [14], as well as the impacts and performance of the organization [6]; [2]; [8]; [13]. ITG guides the use of IT in the company in strategic control and adds value to business, improving decision-making processes [9]; [14]; [17]. The combined use of multi-criteria decision methodologies and soft computing proves to be particularly suitable for Strategic Alignment such as the focal area of COBIT [1].

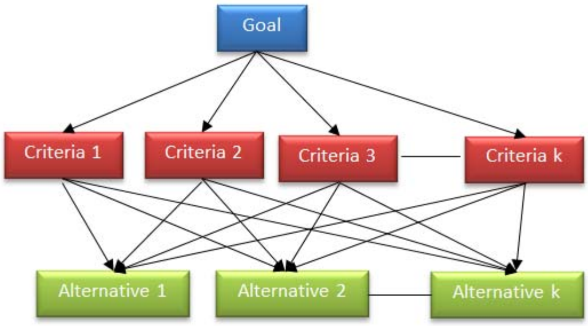
Information technology requires setting or management by the organization or company in order that the information within the company or organization has supported the objectives of the company or organization, resources are used appropriately and responsibly as well as information technology risks are managed appropriately. Successful company or organization is a company or organization that is proven to be able to understand and manage and implement the technology in its activities. Information technology governance in the process of data management is the management of data which is an important asset for the company or organization. Governance of information technology in data management processes that are less good will pose some problems which are weaknesses (vulnerabilities) so that thay would pose threats as the incidence of loss, destruction, theft and wiretapping critical data company or organization. Continuous improvement on the governance of information technology, especially in the data management process is expected to be able to minimize the risk of threats. In order to be able to make improvements governance of information technology, the company or organization must first be able to understand the level of information technology management of its current (as-is) and the level of expected information technology management (to-be) so that corrective steps performed will be effective.

Many measurement methods have been used, but when we get worse data, this will cause some problems. Existing data are sometimes inadequate for problems in real life, because human judgment which include preferences often vague / unclear and can not predict their preference by exact numerical values. So that we need a new model to perform a measurement. In this study using fuzzy logic models in making a decision structured preference maker. Fuzzy theory helps in measuring the concept of uncertainty related to human which is subjective. Two applications of fuzzy namely Fuzzy AHP is used to determine the weight of the specified criteria and Fuzzy TOPSIS to rank of selected alternatives.

## II. PRELIMINARIES

### *A. FAHP*

In this method, first set comparative assessment of each the existing criteria using triangular fuzzy value that shows the comparison between the interests of the criteria.

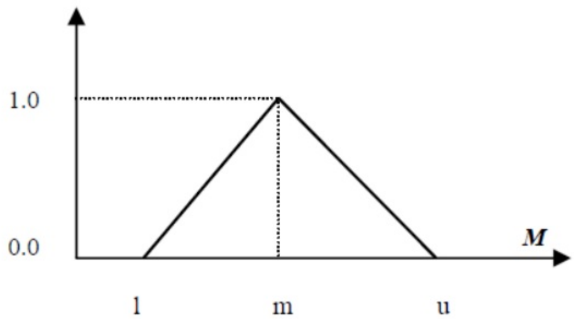



Fix 1. The structure of the hierarchy problem

TABLE 1. The value of linguistic variables with triangular fuzzy numbers

| Variable linguistic | Explanation | Value TF | Value Invers TF |
|---|---|---|---|
| EI | Two elements contribute equality to the objective | 1 1 1 | 1 1 1 |
| MI | Experience and judgment slightly favor one element over another | 1 3 5 | 1/5 1/3 1 |
| SI | Experience and judgment strongly favor one element over another | 3 5 7 | 1/7 1/5 1/3 |
| VSI | One element is favored very strongly over another, its dominance is demonstrated in practise | 5 7 9 | 1/9 1/7 1/5 |
| EI | The evidence favoring one element over another is of the highest possible order of affirmation | 8 9 10 | 1/10 1/9 1/8 |

Triangular fuzzy numbers in Table 1 are denoted by M = {l, m, u}, where M is the set of fuzzy numbers consisting of l, m and u are respectively expressed the smallest possible value, the value of the closest, and the largest possible value.




Fix 2. Triangular Fuzzy Numbers

If X = {x1, x2, x3, ... xn} denotes a set of objects, and G = {g1, g2, g3, ..., gn} denote the set goals. If there is a number m of criteria that will be used for analysis, the obtained M gi 1, M gi2, M gi.3 ... M gi.mi = 1,2, ..., n, where Mgi j (j = 1, 2, ..., n)a triangular fuzzy numbers. The steps used to Further analyzes are as the following :

**Step 1**: defined value of fuzzy synthetic extents (Si) with criteria to i by equation 1.

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \times \left[ \sum_{i=1}^{n} \sum_{j-1}^{m} M_{gi}^{j} \right]^{-1} \quad (1)$$

to get $\sum_{j=1}^{m} M_{gi}^{j}$ , summation surgery fuzzy value of the value of m in the matrix using equation 2.

$$\sum_{j=1}^{m} M_{gi}^{j} = \left( \sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \quad (2)$$

to get $\left[ \sum_{j=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1}$ operations performed fuzzy summation of values Mjgi (j = 1, 2, ..., n) by using equation 3.

$$\sum_{j=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} = \left( \sum_{j=1}^{n} l_j, \sum_{j=1}^{n} m_j, \sum_{j=1}^{n} u_j \right) \quad (3)$$

Then calculate the inverse of the vector in the above equation using equation 4.

$$\left[ \sum_{j=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1} = \left( \frac{1}{\sum_{j=1}^{n} l_j}, \frac{1}{\sum_{j=1}^{n} m_j}, \frac{1}{\sum_{j=1}^{n} u_j} \right) \quad (4)$$

**Step 2**: calculate the degree of possibility, where M1 = (l1, m1, u1) and M2 = (l2, m2, u2) are two triangular fuzzy numbers, so that the degree of likelihood M2 = (l2, m2, u2) ≥ (l1, m1, u1) is obtained from equation (5) and (6)

$$V = M_2 \geq M_1 = hgt\ (M_2 \cap M_1) = \mu_{M2} \quad (5)$$

$$= \begin{cases} 0 & , if \quad m_2 \geq m_1 \\ 1 & , if \quad l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & , otherwise \end{cases} \quad (6)$$

**Step 3**: Compare the degree of likelihood among criteria between numbers fuzzy M1 = (i = 1,2, ..., k) by equation (7).

$$\begin{aligned} &V(M \geq M_1, M_2, \ldots .. M_k) \\ &= V[(M \geq M_1)] \text{ and } (M \geq M_2) \text{ and } \ldots . \text{ and } (M \geq M_k)] \\ &=_{min} V(M \geq M_i),\ i = 1,2, \ldots ..,k \end{aligned} \quad (7)$$

Assuming d (Ai) = minV (Si ≥ Sk) for k = 1,2, ... k; k ≠ i. So we get the value of the weight vector in equation (8).

$$W' = \left( d'(A_1), d'(A_2), \ldots, d'(A_n) \right)^T \quad (8)$$

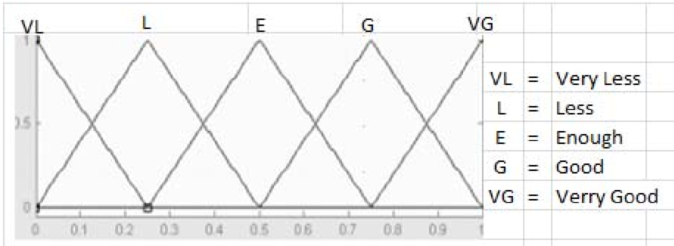
After the weight vector in equation (8) normalized, normalized weight vector obtained is shown in equation (9).

$$W = \left( d(A_1), d(A_2), \ldots, d(A_n) \right)^T \quad (9)$$

Where W is not a fuzzy numbers.

*B. Fuzzy TOPSIS*

Having obtained the weight values for each criterion, then do calculations using TOPSIS method that has been fuzzy, contrast with the TOPSIS method to determine the value criteria for each alternative diractly, on Fuzzy TOPSIS used numbers triangular fuzzy as in figure 3 to represent values for each criterion of each alternative will be selected.




Fix 3. Fuzzy Numbers for assessment criteria.

After each of the alternative criteria rated, then calculate integral total value for each alternative using equation (10).

$$x = I(F) = 1/2(\alpha c+b+(1-\alpha)a) \qquad (10)$$

With h α is the degree of optimism with a value between 0 and 1. Having obtained the total value of the integral on each criterion, they have to be normalized by equation (11).

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \qquad (11)$$

Then do the calculation to get the weight matrix normalized through equation (12).

$$v_{ij} = W_{ij} * r_{ij} \qquad (12)$$

Then the calculated values are positive ideal solution and negative ideal solution value using equation (13).

$$A^+ = \{v_1^+, v_2^+, ...., v_n^+\}$$
$$A^- = \{v_1^-, v_2^-, ...., v_n^-\} \qquad (13)$$

The distance between the alternative with the positive ideal solution is calculated with equation (14).

$$D_i^+ = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \qquad (14)$$

While distance alternative to the negative ideal solution is calculated by the equation (15).

$$D_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \qquad (15)$$

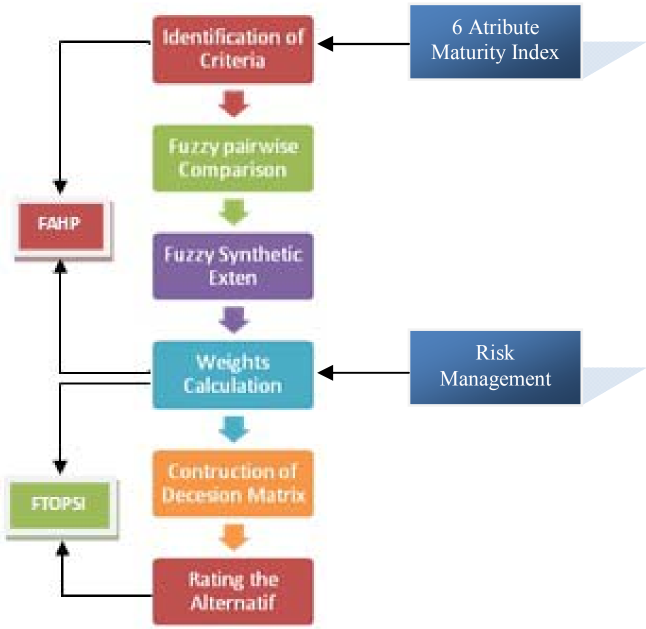
By comparing the distance with the positive and negative ideal solution, then obtained the preference value for each alternatively by equation (16).

$$CC_i = \frac{D_i^-}{D_i^- + D_i^+} \qquad (16)$$

$CC_i$ value obtained from the equation (16) is the final value used to determine the ranking of some of the alternatives that will be selected by the value of the initial rank order starting from the largest value of $CC_i$.

## III. THE PROPOSED METHOD

Research model was designed as shown in figure 4. Stages of research are described based on research model.




Fix 4. Research Model

The initial step in this research is to identify the criteria. The criteria used are taken from the 6 attributes that exist in the COBIT maturity index, AC (Awareness and Communication); PSP (Policies, Standards and Procedures); TA (Tools and Automation); SE (Skills and Expertise; RA (Responsibilities and Accountabilities) and GSM (Goal Setting and Measurement). After getting criterion is calculated using the FAHP that starts with making pairwise comparison matrix of the attributes of maturity indices to quantify the value of the fuzzy synthetic thus gaining weight value of each respective attributes.

The weights of the results of calculations using the FAHP is used to rank search for common risk management in the Bank by using FTOPSIS. The management of risk in this research, ATM (network disconnected); SMS Banking (transaction failed); Software / Hardware (slow connection); Infrastructure (abuse of data).

## IV. RESULT

The first stage in this research is to determine the criteria by considering the value of the maturity index (maturity index) in 6 COBIT maturity attributes that include: Awareness and Communication AC); Policies, Standards and Procedures (PSP); Tools and Automation (TA); Skills and Expertise (SE); Responsibilities and Accountabilities (RA); Goal Setting and Measurement (GSM).

For each of the criteria used, the value of M is given which represents the ratio between the criteria of one another. After the comparison between all the criteria / attributes are set to obtain a matrix as in Table 2.

TABLE 2. Matrix of Comparison of COBIT maturity pairs Fuzzy Value of attributes.

| Criteria | AC | PSP | TA | SE | RA | GSM |
|---|---|---|---|---|---|---|
| AC | 1 1 1 | 1/7 1/5 1/3 | 1 1 1 | 1 3 5 | 1 1 1 | 1/5 1/3 1 |
| PSP | 3 5 7 | 1 1 1 | 1 1 1 | 1 3 5 | 1/5 1/3 1 | 1 1 1 |
| TA | 1 1 1 | 1 1 1 | 1 1 1 | 3 5 7 | 1/5 1/3 1 | 1/7 1/5 1/3 |
| SE | 1/5 1/3 1 | 1/5 1/3 1 | 1/7 1/5 1/3 | 1 1 1 | 1/7 1/5 1/3 | 1/5 1/3 1 |
| RA | 1 1 1 | 1 3 5 | 1 3 5 | 3 5 7 | 1 1 1 | 1 1 1 |
| GSM | 1 3 5 | 1 1 1 | 3 5 7 | 1 3 5 | 1 1 1 | 1 1 1 |

The next step is looking fuzzy value Synthetic extents (Si) using equation (1), so that the gain matrix as in Table 3.

TABLE 3.Nilai Fuzzy Synthetic Extent

| | l | m | u |
|---|---|---|---|
| AC | 0.0534 | 0.1150 | 0.2609 |
| PSP | 0.0885 | 0.1995 | 0.4473 |
| TA | 0.0780 | 0.1502 | 0.3168 |
| SE | 0.0232 | 0.0423 | 0.1305 |
| RA | 0.0984 | 0.2465 | 0.5591 |
| GSM | 0.0984 | 0.2465 | 0.5591 |

Then calculate the degree of possibility among criteria by using equation (3) to get the value of the degree of likelihood criterion.Value of the weight vector generated from Table 4 as calculated using equation (8) are shown in Table 5 (W').

TABLE 4. Values of Fuzzy Synthetic Extent

| | AC | PSP | TA | SE | RA | GSM |
|---|---|---|---|---|---|---|
| AC | 1 | 1 | 1 | 0.812 | 1 | 1 |
| PSP | 1.4294 | 1 | 1.4539 | 0.3644 | 1 | 1 |
| TA | 1.5197 | 1 | 1 | 0.5226 | 1 | 1 |
| SE | 1 | 1 | 1 | 1 | 1 | 1 |
| RA | 0.9661 | 1.2602 | 1.1633 | 0.2158 | 1 | 1 |
| GSM | 0.9661 | 1.2602 | 1.1633 | 0.2158 | 1 | 1 |

Once normalized for each criterion, then the value of the resulting weight vector becomes as shown in Table 5 (W).

TABLE 5. Weights normalized

| Criteria | AC | PSP | TA | SE | RA | GSM |
|---|---|---|---|---|---|---|
| W' | 0.966095 | 1 | 1 | 0.215778 | 1 | 1 |
| W | 0.186437 | 0.19298 | 0.19298 | 0.041641 | 0.19298 | 0.19298 |

Weight vector values produced from Fuzzy AHP method is used to perform calculations with Fuzzy TOPSIS method. Risk management is a process measurement or risk assessment and management strategy development. Strategies adopted among others avoid the risk. The identification of the criteria used in this stage refers to several risks, among others: ATM (Network Disconnected); SMS Banking (Transaction failed); Software / Hardware (Slow Connection); Infrastructure / Data Center (Abuse Data).

Each criteriaon of each risk gives value using triangular fuzzy numbers, as in Table 6.

TABLE 6. Value Weight normalized

| Kriteria | PSP | GSM | AC | RA | SE | TA |
|---|---|---|---|---|---|---|
| ATM | 0,5 0,75 1 | 0,5 0,75 1 | 0,75 1 1 | 0,75 1 1 | 0,25 0,50 0,75 | 0,75 1 1 |
| SW & HW | 0,5 0,75 1 | 0,5 0,75 1 | 0,75 1 1 | 0,75 1 1 | 0,5 0,75 1 | 0,5 0,75 1 |
| SMS Banking | 0,75 1 1 | 0,25 0,25 0,75 | 0,25 0,50 0,75 | 0,5 0,75 1 | 0,75 1 1 | 0,25 0,50 0,75 |
| Infrastruktur | 0,5 0,75 1 | 0,25 0,25 0,75 | 0 0,25 0,5 | 0,5 0,75 1 | 0,75 1 1 | 0 0,25 0,5 |

Matrix triangular fuzzy values obtained in Table 6 is calculated using the total value of the integral equation (10) to obtain the matrix X as in Figure 5 below.

| | | | | | | |
|---|---|---|---|---|---|---|
| | 0,75 | 0,75 | 0,94 | 0,5 | 0,5 | 0,94 |
| X = | 0,75 | 0,75 | 0,94 | 0,94 | 0,75 | 0,75 |
| | 0,94 | 0,5 | 0,5 | 0,75 | 0,94 | 0,5 |
| | 0,75 | 0,5 | 0,25 | 0,75 | 0,94 | 0,25 |

Fix 5. Value Total Integral

By using equations (11) and (12) of the matrix in Figure 5, it was found that the normalized weight matrix V in Figure 6.

| | | | | | | |
|---|---|---|---|---|---|---|
| | 0,062256 | 0,038772 | 0,080956 | 0,332698 | 0,013666 | 0,031118 |
| V= | 0,062256 | 0,038772 | 0,080956 | 0,625472 | 0,020499 | 0,024828 |
| | 0,078027 | 0,025848 | 0,043062 | 0,499047 | 0,025693 | 0,016552 |
| | 0,062256 | 0,025848 | 0,021531 | 0,499047 | 0,025693 | 0,008276 |

Fix 6. Matrix weight normalized

Normalized weighting matrix in Figure 6 the value of the positive ideal solution and negative ideal solution value using equation (13), then the distance between the ideal solution positive alternative is calculated by equation (14), while the distance alternative the negative ideal solution is calculated by equation (15). By comparing the distance between the idealized positive solutions to the negative ideal solution, then obtained the preference value for each alternative on the Table 7 through equation (16).

TABLE 7. Final Value of Alternative Risk and rankings.

| Risk | $CC_i$ | Rank |
|---|---|---|
| ATM | 0.77936419 | 4 |
| SW/HW | 0.87410948 | 1 |
| SMS Banking | 0.84884639 | 2 |
| Infrastructure | 0.81365758 | 3 |

When viewed from the end result is obtained as in Table 7, it can be analyzed that XYZ Bank priority in risk management is a service SW / HW and SMS Banking.
For that need to be made a strategic steps : Form a Steering Committee; Form the Organizing Committee; Develop Road Map Implementation; Doing Gap Analysis; Develop Database management policy; Develop business lines; Clarify Developing Assets; Procure Consultant risk management and information technology; Increase the competence of human resources; Socializee risk management framework.

## V. CONCLUSION

In this study to determine and evaluate the maturity index and risk management in the implementation of IT governance using the FAHP and FTOPSIS in a Bank XYZ. The results of the evaluation showed that the maturity index Skills and Expertise (SE) result smallest weight than other attributes (0.041641), as well as the risk management SW / HW to get very serious concern because scores very high (0.874109). Then, it needs to make a step- strategic move.

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