Risk mitigation of goods procurement process using interpretive structural modelling, MICMAC analysis and house of risk methods

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Abstract. The purpose of this research is to identify risks and causes of risk that occur in the flow of the company's supply chain, identify the linkages between risks and design treatment strategies that can be used to reduce the emergence of risk agents. The research methods used are Interpretive Structural Modelling, MICMAC Analysis, and House of Risk. The identification results show that there are 12 risks and 26 causes. Based on the analysis, the relationship between one risk and other results in 8 levels and 2 quadrants. The results of the analysis also show that 15 causes of risk will be carried out by designing a handling strategy. There are 11 treatment strategies proposed to reduce the probability of risk causes. From this analysis, it can be concluded that the procurement process needs to carry out mitigation based on the highest priority, such as changing the business process to e-procurement, differentiating the format between the revised PR and the original PR, updating the cost evaluation data regularly.

Keywords: House of Risk Methods, Interpretive Structural Modelling, MICMAC Analysis, Procurement, Risk Mitigation

1. Introduction
In general, companies need goods and services to support all activities within the company. To obtain these goods and services the company carries out procurement activities. When carrying out its business activities, the procurement department will face various types of risks and causes of risks that may arise in the procurement process and result in disruption of the smooth running of the overall business process (company). Types of risk and the causes of risk can come from within the company or from outside the company. The emergence of risks in procurement activities should be assessed and mitigated so as not to interfere with the objectives of the company.

One obvious risk is that the entire procurement process is carried out manually, such as making a Purchase Requisition (PR), PR approval process, and issuing a Purchase Order (PO). This causes the procurement process to be slow. The current lead time for the procurement process is 7 to 14 days depending on the number of approvals required in the goods purchase form. This is ineffective and inefficient because approval must be done using the original signature on paper so that when one of the parties concerned has not approved the form, the PO cannot be issued. The procurement process is also not transparent because the user cannot know the progress of the procurement process. There is another problem in the goods and services procurement process, namely the occurrence of PO outstanding delivery. The average outstanding amount in the last 14 months was 49%. This problem
occurs because the goods procurement process does not have a delivery monitoring system and does not use an e-procurement system.

Therefore, research was conducted to identify various other risks that arise in the procurement process. After obtaining the risks, identification of the relationship between risks that influence other risks is carried out and analysis of the relationship between causes and risks is conducted. It needs a proper method to analyse these relationships. One of the appropriate methods for analysing the risk-related relationship is using the Interpretive Structural Modelling (ISM) method. Furthermore, the interrelated elements are sorted from the top level to the key level using the hierarchical structure of Interpretive Structural Modelling (ISM).

The second method is the MICMAC Analysis Method which is used to identify the presence of risk levels in 4 sectors or quadrants. The third method is the House of Risk (HOR) method, which is used to identify each severity value and occurrence value for risks and causes of risk. The severity value and the probability value (occurrence) are used to calculate the Aggregate Risk Potential (ARP) value. This ARP value is a benchmark value to prioritize the causes of risk. Furthermore, the ARP value is processed using the Pareto diagram with the 80/20 principle to find out 20% of the causes of risk which affect the other 80% of risks.

Based on the results of the Pareto diagram and consideration of the relationship between the ISM structure, a mitigation strategy is designed to handle and reduce the occurrence of this risk. The technique used to design a mitigation strategy on the causes of risk is the House of Risk phase 2. It analyse the degree of difficulty value (Dk)of the mitigation strategy and the value of the relationship between the causes of risk and the mitigation strategy to determine the priority of the mitigation that has been designed.

2. Literature Study

2.1. Supply Chain
The supply chain is a network of organizations that are involved, through upstream and downstream relationships, in various processes and activities that generate value in the form of products and services in the hands of end consumers [1].

2.2. Procurement
Procurement is a management activity that makes things happen, and this process depends on superior risk management skills if it is to be effective[2].

2.3. Risk Management
Supply chain risk is defined as the likelihood and impact of unforeseen macro and micro events or conditions affecting any part of the supply chain, leading to operational, tactical, or strategic level failures or deviations[3]. Risk management is a management effort to control the risk of the company’s operational activities by conducting a risk analysis, risk evaluation, and mitigation plans [4]. The risk management program includes the following stages [5]:

- Identify the risks faced;
- Measure or determine the amount of the risk;
- Finding ways to face or manage risks;
- Develop strategies to minimize or control risks;
- Coordinating the implementation of risk management and evaluating the risk management program that has been made

2.4. Interpretive Structural Modelling (ISM)
Interpretative Structural Modelling (ISM) is a modelling technique developed for strategic policy planning. ISM was first created by J.Warfield in 1973, where Warfield defined ISM as a computer-assisted learning process that allows individuals or groups to develop complex relationship maps between various elements involved in complex situations [6].
The first step in ISM processing is to create a Structural Self Interaction Matrix (SSIM), in which the variables are made a contextual relationship by making one variable i and variable j. The next step is to create a Reachability Matrix (RM) by changing V, A, X, and O with the numbers 1 and 0 as shown in table 1. The final step is to create a Canonical Matrix to determine the level through iterations. After there are no more intersections, a model generated by the ISM is then created, which is a model for solving problems, in this case, the development of a sharia cooperative model. From this model, a road map for institutional development (level) will be created[6]. The following is the code to represent the relationship between criteria such as [7]:

- A notation to indicate the criteria in row i does not affect the criteria in column j but the criteria in column j can affect the criteria in row i.
- V notation to indicate the criteria in row i affects the criteria in column j but the criteria in column j do not affect the criteria in row i.
- O notation to indicate the criteria in row i and column j does not affect each other.
- X notation to indicate the criteria in row i and column j influence each other.

|   | 1                      | 2  | 3  | 4  | 5  | 6  | 7  | 8  |
|---|------------------------|----|----|----|----|----|----|----|
| 1 | Less Support from Top Management | X  | V  | V  | O  | V  | V  | X  |
| 2 | Resistance to Change the Middle Management | V  | X  | V  | V  | V  | V  | X  |
| 3 | Poor Lean Training      | A  | O  | O  | O  | O  | X  |
| 4 | Absence of Lean Implementation Team | V  | O  | O  | A  |
| 5 | Lack of Flexible Working Arrangement | O  | O  | A  |
| 6 | Absence of Consultant   | O  | A  |
| 7 | Lack of Reward System   | O  | A  |
| 8 | High Cost/Investment    | O  | A  |

2.5. MICMAC Analysis
MICMAC Analysis aims to analyse the driving power and dependence power of the driving factors as shown in figure 1. MICMAC Analysis is also a verification of the ISM model. Based on MICMAC Analysis, factors are classified into four sectors as follows [9]:

a. Sector 1: Weak driver-weak dependent variables (autonomous).
   Changes in this sector are generally unrelated to the system and may have minor links, although relationships can be strong.

b. Sector 2: Weak driver-strongly dependent variables (dependent).
   Generally, changes in this sector are not free.

c. Sector 3: Strong driver-strongly dependent variables (linkage).
   The variables in this sector must be studied carefully because the relationship between variables is unstable. Any action on these variables will have an impact on others and the feedback on the effect can amplify the impact.

d. Sector 4: Strong drive weak dependent variables (independent).
   The variables in this sector are the remaining part of the system and are called independent variables.
2.6. House of Risk

The House of Risk model uses the degree of correlation between risk events and sources of risk. Adopting the procedure for preparing the House of Quality matrix, the House of Risk matrix phase 1 was developed through the following stages [10]:

1. Identify risk events that can occur in any mapped process (Ei) (Table 2).

   **Table 2. Risk events in procurement process**

| Risk                                           | Code |
|------------------------------------------------|------|
| Evaluator misrepresents price estimation & vendor evaluation | E1   |
| Incorrectly providing vendor recommendations   | E2   |
| Incorrectly determining the price, quantity, or goods | E3   |
| Purchase Requisition is running slowly         | E4   |
| User-provided budgets are lower than market prices | E5   |
| Agreement late extended                        | E6   |
| PO Outstanding Delivery                        | E7   |
| Purchase Order are running slowly              | E8   |
| Procurement of goods or services is not as expected by the user | E9   |
| Item failed to be ordered                      | E10  |
| Item failed to be received                     | E11  |
| PO process is hampered                         | E12  |

2. Identify the source of risk (risk agent) from each risk event (Ai) (Table 3).

   **Table 3. Causes of Risk/Risk Agents in procurement process**

| Cause of Risk                                                                 | Code |
|-------------------------------------------------------------------------------|------|
| The specifications of the goods listed on the offer are not detailed          | A1   |
| The vendor did not provide a breakdown price in detail                       | A2   |
| Cost evaluation data has not been updated                                    | A3   |
| The vendor evaluation form is still too general                               | A4   |
| There is no complete list of Vendors by business category                    | A5   |
| There is no explanation if PR has been revised                               | A6   |
| PR approval is still manual                                                   | A7   |
| PR is still manual                                                            | A8   |
| User does not have SAP access to view purchase history                        | A9   |
| Users only see estimated prices from online sites (for example: Tokopedia, Shopee) | A10  |
| There is no contract monitoring dashboard                                     | A11  |
| Delivery of goods from vendors is not according to the estimated schedule     | A12  |
| Vendors are doing GR / SA late                                                | A13  |
| There is no delivery monitoring dashboard                                     | A14  |
| PO Approval is still manual                                                   | A15  |
| PO making is still manual                                                     | A16  |
| The goods or services do not match the specified specifications or quantities | A17  |
| Vendor changes without user confirmation                                      | A18  |
| Incomplete tender document files                                              | A19  |
| Negotiation based only on the lowest price                                    | A20  |
| The vendor did not confirm the stock of goods available                       | A21  |
| Courier vendor does not carry important documents (delivery pass)             | A22  |
| The vendor does not confirm to the user in advance regarding the delivery schedule | A23  |
| The quality or quantity of goods does not match                               | A24  |
| The budget issuance process and evaluation costs are carried out in parallel | A25  |
| The user does not attach a proposal to purchase goods                         | A26  |
3. Estimating the impact of several risk events (severity), in this case using a scale of 1-10 where 10 indicates an extreme impact (Si) (table 4).
4. Assess the likelihood of occurrence of each source of risk (Occurrence).
5. Develop a relationship matrix by linking each risk source and risk event. The value of the relationship is expressed in Rij (0, 1, 3, 9), where 0 indicates no correlation and 1, 3, 9 indicate low, medium, and high correlation, respectively.
6. Calculating the Aggregate Risk Potential value for each risk source (ARPj) which is determined as a result of the likelihood of events from risk source j and a collection of the causal effects of each risk event caused by risk source j.
7. Ranking risk sources based on a collection of potential risks in descending order (from large to lowest).

Tabel 4. The scale of Severity and Occurrence [11]

| S       | O      |
|---------|--------|
| No      | Rarely |
| Very Slight | Remote |
| Slight  | Very Slight |
| Minor   | Slight |
| Moderate| Low    |
| Significant | Medium |
| Major   | Moderate-High |
| Extreme | High   |
| Serious | Very High |
| Hazardous | Almost Certain |

House of Risk 2 is used to determine the first action/activity to be carried out, considering differences in effects such as the involvement of sources and the level of difficulty in its implementation. The steps are as follows [12]:
1. Select several risk sources with a high priority ranking that is possible using the Pareto diagram analysis of the ARPj, state on the second HOR.
2. Identification of the consideration of actions relevant to the prevention of sources of risk.
3. Determine the relationship between each preventive measure and each source of Ejk risk. Its values (0, 1, 3, and 9) show no correlation, low, medium, and high correlation between measures of k and source j, respectively.
4. Calculate the total effectiveness of the mitigation plan
5. Estimate the degree of difficulty in carrying out each mitigation plan
6. The priority ranking of each action (R) where rank 1 gives the meaning of the action with the highest ETDk

3. Result
3.1. Risks and causes of risk in procurement process
Based on the results of the Focus Group Discussion, it states that there are 12 Risks and 26 Risk agents or causes of risk that occur in the procurement process. The data was obtained from discussions with the Procurement Team and has been confirmed by the Department Head of Procurement Table 5 is a table from the House of Risk phase 1 which shows the correlation value of the relationship between Risk events and Risk agents and the value of Aggregate Risk Potential (ARP).
Table 5. Risk Events

| Risk events                                                                 | E1 | E2 | E3 | E4 | E5 | E6 | E7 | E8 | E9 | E10 | E11 | E12 |
|-----------------------------------------------------------------------------|----|----|----|----|----|----|----|----|----|-----|-----|-----|
| Evaluator misrepresents price estimation & vendor evaluation                | -  | V  | V  | V  | V  | V  | V  | V  | V  | V   | V   | V   |
| Incorrectly providing vendor recommendations                                 | -  | A  | A  | O  | A  | A  | O  | A  | A  | A   | A   | A   |
| Incorrectly determining price, quantity, or goods                           | -  | X  | A  | V  | O  | V  | V  | V  | V  | V   | V   | V   |
| Purchase Requisition is running slowly                                      | -  | A  | O  | V  | V  | V  | V  | V  | V  | V   | X   |     |
| User-provided budgets are lower than market prices                          | -  | V  | V  | V  | V  | V  | V  | V  | V  | V   | V   | V   |
| Agreement late extended                                                     | -  | O  | A  | V  | A  | V  | O  | V  | V  | V   | V   | V   |
| PO Outstanding Delivery                                                     | -  | A  | O  | A  | V  | A  | V  | A  | V  | V   | V   | V   |
| Purchase Order is running slowly                                            | -  | V  | V  | V  | V  | V  | V  | V  | V  | V   | V   | V   |
| Procurement of goods or services is not as expected by the user             | -  | A  | A  | O  | A  | V  | O  | A  | A  | A   | A   | A   |
| Item failed to be ordered                                                   | -  | V  | A  |     |     |     |     |     |     |     |     |     |
| Item failed to be received                                                  | -  | A  |     |     |     |     |     |     |     |     |     |     |
| PO process is hampered                                                      | -  |     |     |     |     |     |     |     |     |     |     |     |

After the SSIM matrix is created, the data is processed into values 1 and 0 according to the provisions V, A, X, O, then the reachability matrix. In the next step, the reachability matrix data will be reprocessed based on the transitivity principle as shown in table 6 and table 7.

Table 6. Reachability Matrix

| E1  | E2  | E3  | E4  | E5  | E6  | E7  | E8  | E9  | E10 | E11 | E12 | Driving power |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|---------------|
| I  | I  | I  | I  | I  | I  | I  | I  | I  | I   | I   | I   | I             |
| 0  | 1  | 0  | 0  | 0  | 0  | 0  | 0  | 0  | 0   | 0   | 0   | 1             |
| 0  | 1  | 1  | 0  | 1  | *1 | 1  | 1  | 1   | 1   | 1   | 1   | 10            |
| 0  | 1  | 1  | 0  | 1   | *1 | 1  | 1  | 1  | 1   | 1   | 1   | 10            |
| 0  | 1  | 1  | 1   | 1   | 1  | 1 | 1  | 1   | 1   | 1   | 1   | 11            |
| 0  | 1  | 0   | 1   | 1   | 1   | 1 | 1   | 1   | 1   | 1   | 1   | 11            |
| 0  | *1 | 0   | 0   | 0   | 1   | 1   | 0   | 1   | 0   | 1   | 0   | 4             |
| 0  | 1  | 0   | 0   | 0   | 0   | 1   | 1   | 0   | 1   | 0   | 1   | 4             |
| 0  | 0   | 1   | 1   | 0   | 1   | 1   | 1   | 1   | 1   | 1   | 1   | 7             |
| 0  | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 1   | 1   | 0   | 1             |
| 0  | *1 | 0   | 0   | 0   | 1   | 1   | 0   | 1   | 1   | 1   | 0   | 6             |
| 0  | 1  | 0   | 0   | 0   | 0   | 0   | 0   | 0   | 1   | 0   | 1   | 3             |
| 0  | 1   | *1 | 1   | 0   | *1 | 1   | 1   | *1  | 1   | 1   | 1   | 10            |

| Dependence power | 1 | 11 | 5 | 5 | 2 | 8 | 8 | 6 | 11 | 7 | 10 | 5 |

Driving power is calculated based on the reachability matrix.
Table 7. Iteration

| Variable | Reachability set | Antecedent set | Intersection set | Level |
|----------|------------------|----------------|------------------|-------|
| E2       | 2                | 1, 2, 3, 4, 5, 6, 7, 8, 10, 11, 12 | 2 | I     |
| E9       | 9                | 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 | 9 | I     |
| E11      | 11               | 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12 | 11 | II    |
| E6       | 6                | 1, 3, 4, 5, 6, 8, 10, 12 | 6 | III   |
| E7       | 7                | 1, 3, 4, 5, 7, 8, 10, 12 | 7 | III   |
| E10      | 10               | 1, 3, 4, 5, 8, 10, 12 | 10 | IV    |
| E8       | 8                | 1, 3, 4, 5, 8, 12 | 8 | V     |
| E3       | 3, 4, 12         | 1, 3, 4, 5, 12 | 3, 4, 12 | VI    |
| E4       | 3, 4, 12         | 1, 3, 4, 5, 12 | 3, 4, 12 | VI    |
| E12      | 3, 4, 12         | 1, 3, 4, 5, 12 | 3, 4, 12 | VI    |
| E5       | 5                | 1, 5 | 5 | VII   |
| E1       | 1                | 1 | 1 | VIII  |

3.2 ISM Hierarchical Structure
The result of 8 iterations shows that 8 levels will form a structural hierarchy of the relationship between risks. It can be seen from figure 2 is an Interpretive Structural Modelling (ISM) hierarchy created using Microsoft Visio.

![ISM Hierarchical Structure](image)

Figure 2. ISM Hierarchical Structure

3.3 MICMAC
Based on the value of the driving power and dependence power in table 7, it will be processed into the MICMAC quadrant. Figure 3 is the result of the MICMAC Analysis.
3.4. House of Risk

a. House of Risk Phase 1

The severity value and the occurrence value of the risk agents are obtained from interviewing four experts within the company, which are Department Head of Procurement, Section Head Vendor Management, Section Head PO&PR dan Section Head Procurement Plan. Table 8 below, House of Risk phase 1, shows the correlation value of the relationship between risk events and risk agents and the value of Aggregate Risk Potential (ARP).

| Risk event (E) | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 | A9 | A10 | A11 | ARP |
|---------------|----|----|----|----|----|----|----|----|----|-----|-----|------|
| E1            | 3  | 4  | 2  | 3  | 4   | 2  | 3  | 2  | 4  | 3   | 2   | 10.5 |
| E2            | 4  | 3  | 2  | 4  | 3   | 2  | 3  | 2  | 4  | 3   | 2   | 10.5 |
| E3            | 3  | 4  | 2  | 3  | 4   | 2  | 3  | 2  | 4  | 3   | 2   | 10.5 |
| E4            | 4  | 3  | 2  | 4  | 3   | 2  | 3  | 2  | 4  | 3   | 2   | 10.5 |
| E5            | 3  | 4  | 2  | 3  | 4   | 2  | 3  | 2  | 4  | 3   | 2   | 10.5 |
| E6            | 4  | 3  | 2  | 4  | 3   | 2  | 3  | 2  | 4  | 3   | 2   | 10.5 |
| E7            | 3  | 4  | 2  | 3  | 4   | 2  | 3  | 2  | 4  | 3   | 2   | 10.5 |
| E8            | 4  | 3  | 2  | 4  | 3   | 2  | 3  | 2  | 4  | 3   | 2   | 10.5 |
| E9            | 3  | 4  | 2  | 3  | 4   | 2  | 3  | 2  | 4  | 3   | 2   | 10.5 |
| E10           | 4  | 3  | 2  | 4  | 3   | 2  | 3  | 2  | 4  | 3   | 2   | 10.5 |
| ARP           | 80 | 72 | 60 | 56 | 52   | 48 | 44 | 40 | 36 | 32   | 28   | 240  |

b. Evaluation

At this stage, an evaluation of risk events is carried out to identify which risk agent will be treated first. Figure 4 is a Pareto diagram of risk agents and ARP values; the Pareto diagram depicts the 80/20 principle [13]:

![Figure 4. Pareto Diagram of risk agents and ARP values](image-url)
c. House of Risk Phase 2 (Mitigation Plan)

After getting the ARP value, a mitigation plan is made to overcome the risk agents with the highest ARP value. Table 9 is a mitigation plan that has been obtained from brainstorming with the supervisors. The results of the table 10 states that there are 11 Mitigation Plan or proposed to reduce the causes of risk.

Table 9. Correlation Between Risk Agent and Mitigation Plan

| Mitigation Plan (PA₁) | Kode | Risk agents (Aᵢ) | Code | Correlation |
|-----------------------|------|------------------|------|-------------|
| Create Purchase Order monitoring dashboard | PA₁ | There is no delivery monitoring dashboard | A₁₄ | 9 |
| Updating the cost evaluation data regularly | PA₂ | Cost evaluation data has not been updated | A₁ | 9 |
| Changing the business process to e-procurement | PA₃ | PO making is still manual | A₁₆ | 9 |
| | | Not all users have SAP access to view purchase history | A₉ | 9 |
| | | PO Approval is still manual | A₁₅ | 9 |
| | | PR creation is still manual | A₃ | 9 |
| | | PR approval is still manual | A₂ | 9 |
| | | Vendor changes without user confirmation | A₁₈ | 9 |
| Make budget data for the procurement of goods for each division | PA₄ | The budget release process and evaluation costs are carried out in parallel | A₂₅ | 9 |
| Make punishment for vendors who have poor performance | PA₅ | Vendors are doing GR / SA late | A₁₃ | 9 |
| Re-confirm to the vendor regarding the price quote | PA₆ | The vendor did not provide a breakdown price in detail | A₂ | 9 |
| Require all users to create and attach proposals to purchase goods | PA₇ | The user does not attach a proposal to purchase goods | A₁₆ | 9 |
| Differentiating the format between the revised PR and the original PR | PA₈ | There is no explanation if PR has been revised | A₆ | 9 |
| Send a reminder email when the PO has been sent | PA₉ | Delivery of goods from vendors is not according to the estimated schedule | A₁₂ | 9 |
| Ask the vendor to provide detailed product specifications | PA₁₀ | The specifications of the goods listed on the offer are not detailed | A₁ | 3 |
| Negotiating with all vendors who provide price quotes | PA₁₁ | Negotiation based only on the lowest price | A₃₀ | 3 |

Table 10. House of Risk Phase 2
4. Conclusions and Recommendations

The Interpretive Structural Modelling (ISM) is an effective method to analyse the relationship among risks that give visual aid to determine the root cause of the risks. In this study, it was found that the procurement process consists of 12 risks and 26 causes of risk. It is shown that the evaluator misrepresents price estimation & vendor evaluation (E₁) is at the bottom of ISM Hierarchical Structure (Level VIII) that leads to the risks of procurement of goods or services is not as expected by the user (E₉) and incorrectly providing vendor recommendations (E₂) at the top of ISM Hierarchical Structure (Level I). While MICMAC analysis found that PO process is hampered (E₁₂) is at Sector III which means all the risks have a strong linkage to this risk therefore need to be carefully studied. The results of House of Risk analysis found 3 main priorities for dealing with risk, namely changing the business process of procurement to e-procurement (PA₃), differentiating the format between the revised PR and the original PR (PA₂), updating the cost evaluation data regularly (PA₂).

Based on the results of data processing and analysis, the following are suggestions that can be given to company, namely that the company should conduct a review of the risks that occur in the procurement process, review the procurement business process and consider the strategies that have been proposed. The company need to consider to used e-procurement system to reduce the risks found in this study.

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