Risk analysis on crucial sector priority using Analytical Hierarchy Process (AHP) and House of Risk (HoR)

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ABSTRACT – There are many sectors in an company can trigger the risks, which are internal factor and external factor. By means of Risk Management, those risks can be managed. A decision making using Analytical Hierarchy Process (AHP) method was to find the elected risks as the risks mitigation then will be managed using House of Risk (HOR) method. The Risk Cost, there is a rise of Cost of Good Sold (CoGS) that can decrease the profit, was the largest risk weight, 0.132 point. And it was known that the high risk for the obstruction of target completion was caused by the shifting of most of the production schedule, so that those risks were needed to be managed and mitigated.

INTRODUCTION

The scientific approach for the risk management is to well manage the company’s risks so that managing the risks in the right on the target. The smarter a company to manage the risks then an company will survive and be able to run the plan.

PT Pindad (Persero) is a manufacture industry on producing military warfare and national security products since 1983 such as fire weapons, munitions, combat vehicles, casting forging for train, military and commercial explosives, and also service of cyber security. From these explanations, managing the risks is become crucial to run the company.

The risk management is divided into three categories, which are financial risk, operational risk, and strategic risk as shown on Table 1.

<table>
<thead>
<tr>
<th>Risk Sector</th>
<th>Risks</th>
<th>Risk Level</th>
<th>Risk Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Risk of operational cost, the rise of sales and marketing function</td>
<td>High</td>
<td>Bisnis Hankam</td>
</tr>
<tr>
<td></td>
<td>Risk of currency fluctuation</td>
<td>High</td>
<td>Div. Keuangan</td>
</tr>
<tr>
<td></td>
<td>Risk of the raise of interest loan</td>
<td>High</td>
<td>Div. Keuangan</td>
</tr>
<tr>
<td>Operational</td>
<td>Risk of cost – the raise of cost of good sold that decreasing profit</td>
<td>High</td>
<td>Div. Senjata</td>
</tr>
<tr>
<td></td>
<td>Risk of supply lateness</td>
<td>High</td>
<td>Div. Alat Berat</td>
</tr>
<tr>
<td></td>
<td>Risk of quality</td>
<td>High</td>
<td>Div. Senjata</td>
</tr>
<tr>
<td>Strategy</td>
<td>Risk of weak competitiveness</td>
<td>High</td>
<td>Div. Alat Berat</td>
</tr>
<tr>
<td></td>
<td>Risk of market share decreasing for heavy vehicle division</td>
<td>High</td>
<td>Div. Alat Berat</td>
</tr>
<tr>
<td></td>
<td>Risk of sales target</td>
<td>High</td>
<td>Bisnis Hankam</td>
</tr>
</tbody>
</table>

From Table 1, it is obvious that the three risk sectors are crucial to be well managed and mitigated. However, the company may not mitigate all those risks at the same time, so the company must choose the crucial risks in a priority.

This research objectives were selecting the crucial risk to be a priority managed using Analytical Hierarchy Process (AHP), then mitigated the selected risk using House of Risk (HoR).

METHODS

Analytical Hierarchy Process (AHP)

The AHP was been used in this research to assess the risk in selecting a priority crucial risk. The AHP was used to make a priority of risk of crucial sector priority objectives, identifying of risks indicators, also assessing the potential impact and weight of all alternatives, so that the risk can be selected.[1]

AHP is consist of determining the objectives, constructing the hierarchy structure, composing pairwise comparison matrix, matrix normalization, matrix consistency test, hierarchy ratio consistency test, and alternative ranking based on the weight.[2]
The objective for AHP was Risk of Crucial Priority, there are 3 criteria, which were Strategy, Operational, and Financial.

For Strategy criteria there were 6 sub criteria, which were Promotion, Marketing, Exhibition, Market Research, Innovation, and Improvement. For Operational criteria there were 5 sub criteria, which were Vendor, Punctuality, Resources, Profit, and Bill of Materials, and for Financial criteria there were 3 sub criteria, which were Natural Hedging, Foreign Currency, and National Economy.

Meanwhile, for each criteria, there were alternatives, 3 for Strategy, 3 for Operational, and 3 for Financial, which were consecutively Risk of Unachieved Sales Target, Risk of Market Share Decrease, Risk of Low Competitiveness, Risk of Quality, Risk of Supply Lateness, Risk of Cost, Risk of the Raise of Interest Rate, Risk of Currency Rate Fluctuation, and Risk of the Raise of Cost.

The AHP hierarchy structure as shown in Figure 1.

A series of questionnaires were deployed to determine the input of pairwise comparison matrix.

The House of Risk (HoR)

This research adapted AHP model to determine the priority risk to be mitigated.

Suppose $O_j$ is the risk agent $j$ for probability of occurrence, $S_i$ is the impact of severity when the risk event $i$ was occurred, and $R_{ij}$ is the correlation between risk agent $j$ and risk event $i$, then the aggregate risk potential of risk agent will be formulated as,

$$ARP_j = O_j \sum_i S_i R_{ij}$$

There 2 phases in HoR, which are HoR phase 1, is a process to identify the risk, and HoR phase 2 is the action of risk mitigation. The result from HoR phase 1 will be processed in HoR phase 2. [1][5]

The procedure of HoR phase 1 is:
1. Identify the business process.
2. Identify the risk agent and assessing the likelihood of occurrence for each risk agent
3. Assessing the risk impact (severity)
4. Develop a relationship matrix
5. Calculate $ARP_j$ using formula (1)
6. Ranking risk agents from large to low values

For HoR phase 2, to determine which agent is to be done first, the procedure as follows,
1. Select the high priority of the risk using Pareto analysis.
2. Risk mitigation by identifying the risk, $PA_k$
3. Determine the relationship for each preventive action and for each risk agent, $E_{jk}$
4. Calculate total effectiveness of risk mitigation

$$TE_k = \sum_i ARP_j E_{jk}$$

while $E_{jk}$ is a cross multiplication of $ARP_j$ and $E_{jk}$
5. Determine the degree of difficulties in performing each action, $D_k$
6. Calculate the ratio of total effectiveness to difficulty, $ETD_k$

$$ETD_k = \frac{TE_k}{D_k}$$ (3)

7. Determine risk mitigation priority. $R_k$, Rank 1 is the highest $ETD_k$

RESULT AND DISCUSSION

After collecting all questionnaires, then all the results were converted to pairwise comparison matrix. The example of pairwise comparison matrix based on the result of questionnaire, as follows

**Table 2. Geometric Mean Pairwise Comparison Matrix for questionnaire of Criteria**

<table>
<thead>
<tr>
<th>No</th>
<th>Questionnaire of Criteria</th>
<th>Assessment Geometric Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Strategy – Financial</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Strategy – Operational</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Operational – Financial</td>
<td>5</td>
</tr>
</tbody>
</table>

**Table 3. Pairwise Comparison Matrix of Criteria**

<table>
<thead>
<tr>
<th>Financial</th>
<th>Operational</th>
<th>Strategy</th>
<th>Eigen Vector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>1</td>
<td>0.2371</td>
<td>0.4807</td>
</tr>
<tr>
<td>Operational</td>
<td>4.2172</td>
<td>1</td>
<td>1.0000</td>
</tr>
<tr>
<td>Strategy</td>
<td>2.0801</td>
<td>1.0000</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>7.2972</td>
<td>2.2371</td>
<td>2.4807</td>
</tr>
</tbody>
</table>

And the value of $\lambda_{max} = 3.0661$, $CI = 0.0331$, and $CR = 0.0570$

The result of all pairwise comparison matrixes, the value of consistency ratio for all matrixes were less than 0.1, it means that consistency ratio was consistent.

From several steps of AHP procedure, it was known that the selected criterion was the Raise of Cost, there was a raise of cost of goods sold (CoGS) and it will decrease the profit, has the largest weight, was 0.132 point. So that the Raise of Cost criteria was a crucial sector priority and then this criterion will be risk mitigated to lowering the risk. [6]

The list of variables of risk event and risk agent based on Financial risk, as follows

**Table 4. List of Risk Variable**

<table>
<thead>
<tr>
<th>No</th>
<th>Risk Event (E1 – E17)</th>
<th>Risk Agent (A1 – A17)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Increasing of labor wage</td>
<td>Regulation of wages</td>
</tr>
<tr>
<td>2</td>
<td>Increasing of raw materials cost</td>
<td>Raw materials were difficult to find</td>
</tr>
<tr>
<td>3</td>
<td>Raw materials defective</td>
<td>Raw material inspection was not good</td>
</tr>
<tr>
<td>4</td>
<td>Production components lateness</td>
<td>Troubled Vendor</td>
</tr>
<tr>
<td>5</td>
<td>Decreasing raw materials quality</td>
<td>Lack of maintenance for raw materials</td>
</tr>
<tr>
<td>6</td>
<td>Electricity break down</td>
<td>System was totally breakdown</td>
</tr>
<tr>
<td>7</td>
<td>Work accident</td>
<td>Operator error</td>
</tr>
<tr>
<td>8</td>
<td>Producing failure of the components</td>
<td>Lack of accuracy from operator</td>
</tr>
<tr>
<td>9</td>
<td>Machine break down</td>
<td>Infeasible machine</td>
</tr>
<tr>
<td>10</td>
<td>Unconformity of assembly</td>
<td>The operators were not well train</td>
</tr>
<tr>
<td>11</td>
<td>Unconformity of product quality to international standard</td>
<td>Not following the SOP</td>
</tr>
<tr>
<td>12</td>
<td>Machines are not in optimum condition</td>
<td>Lack of machine maintenance</td>
</tr>
<tr>
<td>13</td>
<td>Waste of electricity</td>
<td>There was inactive facility</td>
</tr>
<tr>
<td>14</td>
<td>Work in process goods were stacked</td>
<td>Numberless machines</td>
</tr>
<tr>
<td>15</td>
<td>Delayed completion target</td>
<td>Missed of scheduling</td>
</tr>
<tr>
<td>16</td>
<td>Over time</td>
<td>Potency of completion lateness</td>
</tr>
<tr>
<td>17</td>
<td>Rework and reject on product</td>
<td>High difficulty to meet product specification</td>
</tr>
</tbody>
</table>
Calculation were made to find the impact value of the risk event, the probability value of the risk agent, and the calculation of the aggregate risk potential for HoR phase 1 as shown in Table 5.

Table 5. House of Risk Phase 1

<table>
<thead>
<tr>
<th>Risk Event</th>
<th>Risk Agent</th>
<th>Severity of Risk Agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>A1</td>
<td>5.0</td>
</tr>
<tr>
<td>E2</td>
<td>A2</td>
<td>0.3</td>
</tr>
<tr>
<td>E3</td>
<td>A3</td>
<td>0.0</td>
</tr>
<tr>
<td>E4</td>
<td>A4</td>
<td>0.0</td>
</tr>
<tr>
<td>E5</td>
<td>A5</td>
<td>0.0</td>
</tr>
<tr>
<td>E6</td>
<td>A6</td>
<td>0.0</td>
</tr>
<tr>
<td>E7</td>
<td>A7</td>
<td>0.3</td>
</tr>
<tr>
<td>E8</td>
<td>A8</td>
<td>0.3</td>
</tr>
<tr>
<td>E9</td>
<td>A9</td>
<td>0.0</td>
</tr>
<tr>
<td>E10</td>
<td>A10</td>
<td>0.0</td>
</tr>
<tr>
<td>E11</td>
<td>A11</td>
<td>0.0</td>
</tr>
<tr>
<td>E12</td>
<td>A12</td>
<td>0.0</td>
</tr>
<tr>
<td>E13</td>
<td>A13</td>
<td>0.0</td>
</tr>
<tr>
<td>E14</td>
<td>A14</td>
<td>0.0</td>
</tr>
<tr>
<td>E15</td>
<td>A15</td>
<td>0.0</td>
</tr>
<tr>
<td>E16</td>
<td>A16</td>
<td>0.0</td>
</tr>
<tr>
<td>E17</td>
<td>A17</td>
<td>0.0</td>
</tr>
</tbody>
</table>

By doing a ranking of the Aggregate Risk Potential from Table 5, [3] a Pareto can be drawn as follows,

![Figure 2. Pareto Diagram of ARP](image)

From Figure 2, it was known that there were 2 risk agents with the highest rank, which were A16 and A15, so that 2 risk agents will be a priority to be mitigated.[3][4]

On the HoR phase 2 form the result of HoR phase 1 as follows,

Table 6. House of Risk Phase 2

<table>
<thead>
<tr>
<th>Risk Agent</th>
<th>Preventive Action</th>
<th>Aggregate Risk Potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>A16</td>
<td>9</td>
<td>1,251</td>
</tr>
<tr>
<td>A15</td>
<td>6.3</td>
<td>987</td>
</tr>
</tbody>
</table>

Total Effectiveness of Action: 17,510
Degree of Difficultly Performing Action: 3.7
Effectiveness to Difficult Ratio: 4,775
Rank of Priority: 2

Referring Table 6, a risk mitigation was taken as follows

Table 7. Preventive Action Ranking

<table>
<thead>
<tr>
<th>Code</th>
<th>Preventive Action</th>
<th>Effectiveness to Difficult Ratio</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA2</td>
<td>Monitoring and synchronizing for the whole production schedule to match to the actual</td>
<td>5,292</td>
<td>1</td>
</tr>
</tbody>
</table>
production floor, whether the in-progress schedule or upcoming schedule.

| PA1   | Doing lobbying with the customer before the schedule is being agreed and also agree to make some allowance to the schedule | 4,775 | 2 |

The last step on HoR phase 2 is risk mapping, and here is the probability (likelihood) and the severity for risk agent that needed to be mitigated.

### Table 8. Probability (Likehood) and Severity

<table>
<thead>
<tr>
<th>Code</th>
<th>Risk Identification</th>
<th>Probability (Likehood)</th>
<th>Severity</th>
</tr>
</thead>
<tbody>
<tr>
<td>A15</td>
<td>Missed of scheduling</td>
<td>Possible (3)</td>
<td>Critical (4.33)</td>
</tr>
<tr>
<td>A16</td>
<td>Potency of completion lateness</td>
<td>Possible (3)</td>
<td>Moderate (3.33)</td>
</tr>
</tbody>
</table>

And a risk mapping for Table 8 is as follows,

![Risk Mapping Diagram](image_url)

From the result of AHP and continued by the House of Risk, the occurred priorities must be anticipated by the company. Those priority risks are missed of production schedule and potency of completion lateness, become a high risk to the financial risk, the increase of cost of goods sold that might be lowering the income, and it might bring up another risk such as a cost penalty due to completion lateness, and also it might decrease the company image.

### CONCLUSION

Robust result to the priority crucial risk for all risk was Operational Risk. Based on the AHP method the selected alternative is Cost Risk (increase of cost of goods sold will decrease profit) by 0.132 point on Operational sector at Divisi Senjata (Weapon Division). Based on House of Risk method from the selected alternative is Missed of production scheduling and Potency of completion lateness. These risks are mitigated with the action plan for those risks are Monitoring and synchronizing for the whole production schedule to match to the actual production floor, whether the in-progress schedule or upcoming schedule, and Doing lobbying with the customer before the schedule is being agreed and also agree to make some allowance to the schedule.

### REFERENCES


