

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

Wahyukaton<sup>1</sup> and Mohamad Refaldi FV<sup>1</sup>

<sup>1</sup>Industrial Engineering Department, Faculty of Engineering, Universitas Pasundan, Bandung 40153, Indonesia.

**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.

**ARTICLE HISTORY**

Revised: 9<sup>th</sup> August 2021

Accepted: 24<sup>th</sup> August 2021

**KEYWORDS**

*Risk Management*  
*Analytical Hierarchy Process*  
*House of Risk*  
*Risk Mitigation*

## 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 1.** Risk Assessment (2019)

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

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.

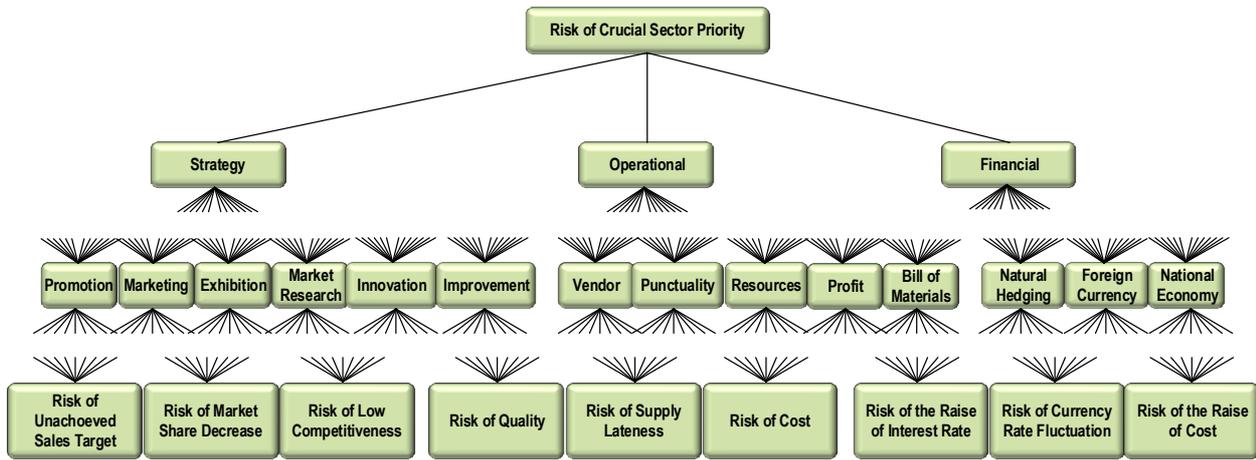


Figure 1. Hierarchy Structure

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,

$$ARP_j = O_j \sum_i S_i R_{ij} \tag{1}$$

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

$$TE_k = \sum_i ARP_j E_{jk} \tag{2}$$

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,  $ETD_k$

$$ETD_k = TE_k / D_k \tag{3}$$

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

No	Questionnaire of Criteria	Assessment			Geometric Mean
		R1	R2	R3	
1	Strategy – Financial	3	3	1	2.0801
2	Strategy – Operational	1	1	1	1.0000
3	Operational – Financial	5	5	3	4.2172

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

	Financial	Operationa l	Strategy	Eigen Vector
Financial	1	0.2371	0.4807	0.1456
Operational	4.2172	1	1.0000	0.4760
Strategy	2.0801	1.0000	1	0.3784
Total	7.2972	2.2371	2.4807	1.0000

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

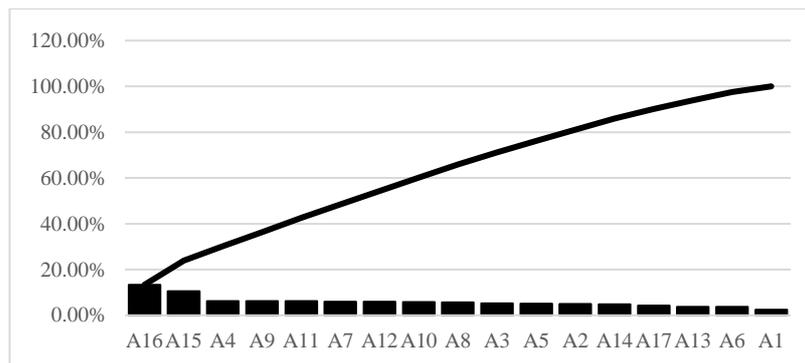
No	Risk Event (E1 – E17)	Risk Agent (A1 – A17)
1	Increasing of labor wage	Regulation of wages
2	Increasing of raw materials cost	Raw materials were difficult to find
3	Raw materials defective	Raw material inspection was not good
4	Production components lateness	Troubled Vendor
5	Decreasing raw materials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

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

Risk Event	Risk Agent																	Severity of Risk Agent
	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	
E1	5.0	0.3	1.7	0.0	0.3	0.7	4.0	2.3	2.0	6.0	4.0	2.0	0.3	0.7	1.3	3.3	3.3	3.67
E2	0.3	9.0	4.0	7.0	6.0	0.0	3.0	4.0	3.0	4.0	4.0	3.0	3.0	3.0	6.0	9.0	6.0	4.33
E3	0.0	4.0	9.0	7.0	6.0	3.0	3.0	5.0	3.0	6.0	6.0	3.0	3.0	3.0	4.0	9.0	6.0	3.67
E4	0.0	9.0	6.0	9.0	4.0	0.3	0.3	1.3	0.3	2.3	3.3	0.3	0.3	0.3	6.3	9.0	0.3	4.00
E5	0.0	4.0	7.0	9.0	7.0	0.3	0.3	1.3	3.0	2.3	2.3	0.3	0.3	2.3	5.0	9.0	5.0	3.00
E6	0.0	0.3	0.3	0.0	1.3	9.0	3.0	1.0	3.0	2.0	3.0	3.0	0.0	0.0	2.0	5.0	1.0	3.00
E7	1.3	0.0	1.3	1.0	1.0	3.3	8.0	6.0	6.0	5.0	6.0	4.0	1.0	1.0	2.0	5.0	2.0	3.00
E8	2.3	7.0	8.0	6.0	8.0	6.0	8.0	8.0	8.0	8.0	8.0	8.0	3.0	5.0	7.0	8.0	5.0	3.30
E9	2.3	0.0	2.0	2.0	1.0	5.0	6.0	6.0	9.0	8.0	9.0	6.3	6.3	3.0	7.0	6.0	5.0	3.00
E10	3.0	1.0	5.0	5.0	5.0	6.0	6.0	6.0	6.0	9.0	9.0	8.0	5.3	5.3	7.0	8.0	6.0	3.00
E11	2.0	2.3	5.3	5.3	5.3	5.0	6.0	6.0	6.0	7.0	9.0	6.0	4.0	5.0	5.3	5.3	6.0	2.33
E12	1.3	0.3	2.3	2.3	1.0	4.0	5.0	5.0	8.0	7.0	7.0	9.0	5.3	5.0	5.0	6.0	6.3	2.67
E13	1.3	0.0	1.0	1.0	1.0	4.0	7.0	5.0	7.0	6.0	6.0	7.0	6.3	6.0	5.0	7.0	4.0	3.00
E14	0.0	2.0	4.0	4.0	5.0	4.0	5.0	5.0	6.0	6.0	6.0	4.0	2.0	5.0	6.0	5.0	4.0	3.33
E15	2.7	7.0	6.0	6.0	7.0	6.0	9.0	7.0	8.0	7.0	7.0	6.0	4.0	7.0	9.0	9.0	6.3	4.33
E16	5.0	2.3	2.7	2.7	2.7	5.3	4.3	4.3	6.0	6.3	6.3	6.0	4.3	9.0	9.0	9.0	2.3	3.33
E17	2.3	4.0	6.0	6.0	6.0	2.7	6.0	6.0	5.3	7.0	9.0	8.0	4.3	7.0	9.0	9.0	2.3	4.00
Occurate of Agent	2.33	2.33	2.00	2.33	2.00	1.67	2.00	2.00	2.00	1.67	1.67	2.00	2.00	2.00	3.00	3.00	1.67	
Aggregate Risk Potential	227.11	460.44	496	585.67	471.78	346.48	558.22	530.00	585.33	547.96	578.52	549.33	347.78	454.89	987.00	1251.00	393.33	
Priority of Risk Agent	17	12	10	3	11	16	6	9	4	8	5	7	15	13	2	1	14	

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

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

Risk Agent	Preventive Action		Aggregate Risk Potential
	PA1	PA2	
A16	9	7	1,251
A15	6.3	9	987
Total Effectiveness of Action	17,510	17,640	
Degree of Difficulty Performing Action	3.7	3.3	
Effectiveness to Difficult Ratio	4,775	5,292	
Rank of Priority	2	1	

Referring Table 6, a risk mitigation was taken as follows

**Table 7.** Preventive Action Ranking

Code	Preventive Action	Effectiveness to Difficult Ratio	Rank
PA2	Monitoring and synchronizing for the whole production schedule to match to the actual	5,292	1

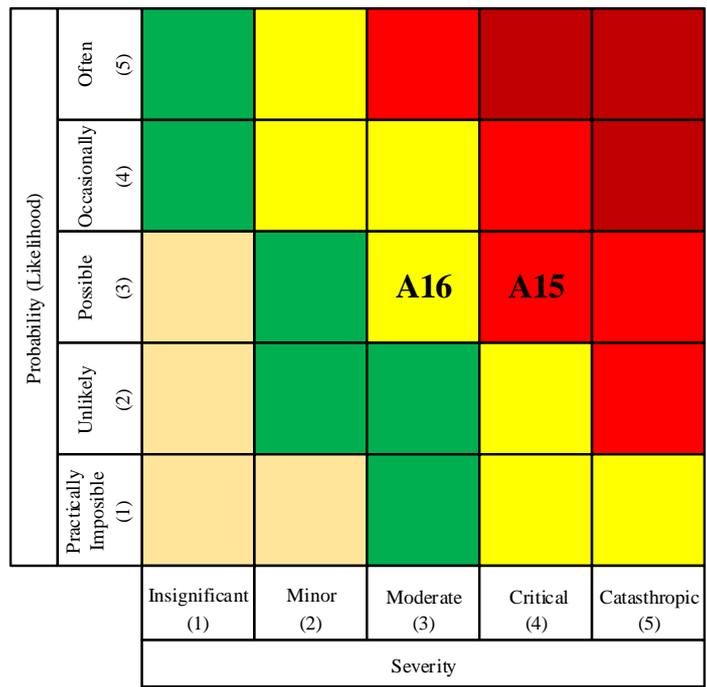
	production floor, whether the in-progress schedule or upcoming schedule.		
PA1	Doing lobbying with the customer before the schedule is being agreed and also agree to make some allowance to the schedule	4,775	2

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 (Likelihood) and Severity

Code	Risk Identification	Probability (Likelihood)	Severity
A15	Missed of scheduling	Possible (3)	Critical (4.33)
A16	Potency of completion lateness	Possible (3)	Moderate (3.33)

And a risk mapping for Table 8 is as follows,



**Figure 3.** Risk Mapping

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**

[1] I. Nyoman Pujawan and Laudine H. Geraldin, House of risk: a model for proactive supply chain risk management, *Business Process Management Journal*, Vol 15 No. 6, pp 953-967, 2009, DOI: 10.1108/14637150911003801

[2] Thomas L. Saaty, Decision making with the analytic hierarchy process, *International Journal of Services Sciences*, Vol 1 No.1., (2008)

- [3] Masri, P., *Disain Mitigasi Risiko Rantai Pasok UMKM Produk Pakaian Kota Bandung Dengan Pendekatan Supply Chain Risk Management*, Universitas Pasundan, (2016).
- [4] Riana Magdalena, Vannie, Analisis Risiko Supply Chain Dengan Model House Of Risk (Hor) Pada Pt Tatalogam Lestari, *Jurnal Teknik Industri*, Vol. 14, No. 2, pp 53-62 (2019)
- [5] Ackermann F., C Eden, T Williams and S Howick, Systemic risk assessment: a case study, *Journal of the Operational Research Society*, Vol. 58, No. 1 (2007) doi:10.1057/palgrave.jors.2602105
- [6] Nur Eko Wahyudin and Imam Santoso, Modelling of Risk Management for Product Development of Yogurt Drink Using House of Risk (HOR) Method, *The Asian Journal of Technology Management*, Vol. 9 No. 2: pp 98-108, (2016), doi: <http://dx.doi.org/10.12695/ajtm.2016.9.2.4>