

# Aggravate or Mitigate? How Cost Analysis Associated into Risk Management Process

Winda Nur Cahyo<sup>1a♦</sup>, Eky Fasich Trialopa<sup>1b</sup>, Hari Purnomo<sup>1c</sup>

**Abstract.** *In most of the research in the area of risk management, the result stops at proposing the mitigation strategies. The number of studies on associating cost analysis into the risk management process is very limited. This paper proposes a practical method of how cost analysis can be associated with the risk management process, especially in manufacturing. The process of risk management is conducted, as usual, started by selecting the potential risk and finding significant causes. Then, a risk map and its rubric of risk likelihood and severity are developed. The significant reasons are plotted into it to select the priority of the major causes, and the proposed mitigation strategy is developed. Then, the proposed strategy is compared with the current policy based on the cost generated using the developed equation. The result shows the proposed mitigation strategy is selected because it saves approximately IDR 2 million per order. It indicates that cost analysis can be successfully associated with the risk mitigation process and generates a comprehensive recommendation to the decision-maker.*

**Keywords:** *cost analysis, risk management, cost of risk mitigation, mitigation strategies, cost mitigation analysis*

## I. INTRODUCTION

Risk Management methodology has been flourishing in recent years since the ISO 31000 was published. The research area using this methodology spreads from (1) finance as in Bandalay, Shanker, and Şatır (2018), Chen, Chuang, Huang, and Shih (2019), Ojeka et al. (2019), Organ and Stapleton (2019), and Yang, Wang, and Ren (2019), (2) disaster as in Etinay, Egbu, and Murray (2018), González, Monsalve, Moris, and Herrera (2018), Maes et al. (2018), Mashi, Oghenejabor, and Inkani (2019) and Ritchie and Jiang (2019), to (3) supply chain management as in Liu, Liu, and Liu (2018), Oger, Bénaben, Lauras, and Montreuil (2018), Rostamzadeh, Ghorabae, Govindan, Esmaeili, and Nobar (2018), Valinejad and Rahmani (2018), and Abdel-Basset, Gunasekaran, Mohamed, and Chilamkurti (2019). However, it is argued that most of the research in

risk management focuses on proposing mitigation strategies to reduce the risk. The study to analyze the mitigation strategy based on cost comparison is limited. Among those are Singh (2017), Galve et al. (2016), Duan, Zhang, Wang, and Fan (2019), Li and Zhou (2020), and Sherwin, Medal, and Lapp (2016). Galve et al. (2016) utilize cost analysis to analyze the mitigation strategy in the area of disaster management. Research by Sherwin et al. (2016) and Singh (2017) is more focused on the cost-effectiveness in the mitigation strategies but a different area: supply chain and public policy, respectively. Both pieces of research by Duan et al. (2019) and Li and Zhou (2020) are in the area of environmental and disaster. This circumstance leads to a research opportunity to associate cost analysis in determining the mitigation strategies. The research presented in this article, as well as the originality of this research, is dragging the risk management even further to associating cost analysis into risk mitigation in the manufacturing industry, especially to determine that the mitigation is more cost-effective compare to leaving the risk as it is (or do nothing strategy).

To verify the feasibility that cost analysis can be associated with the process of selecting the risk mitigation strategy, a case study is presented. The case is selecting a mitigation strategy to reduce the defect of the product "Z" in a glove company in Indonesia. The reason for choosing

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<sup>1</sup> Department of Industrial Engineering, Faculty of Industrial Technology, Universitas Islam Indonesia, Jl. Kaliurang km 14.4, Sleman, Yogyakarta, Indonesia, 55584.

<sup>a</sup> email: [winda.nurcahyo@uii.ac.id](mailto:winda.nurcahyo@uii.ac.id)

<sup>b</sup> email: [ekyfasich07@gmail.com](mailto:ekyfasich07@gmail.com)

<sup>c</sup> email: [ha\\_purnomo@uii.ac.id](mailto:ha_purnomo@uii.ac.id)

♦ corresponding author

Submitted: 27-02-2020      Revised: 17-04-2020

Accepted: 17-06-2020

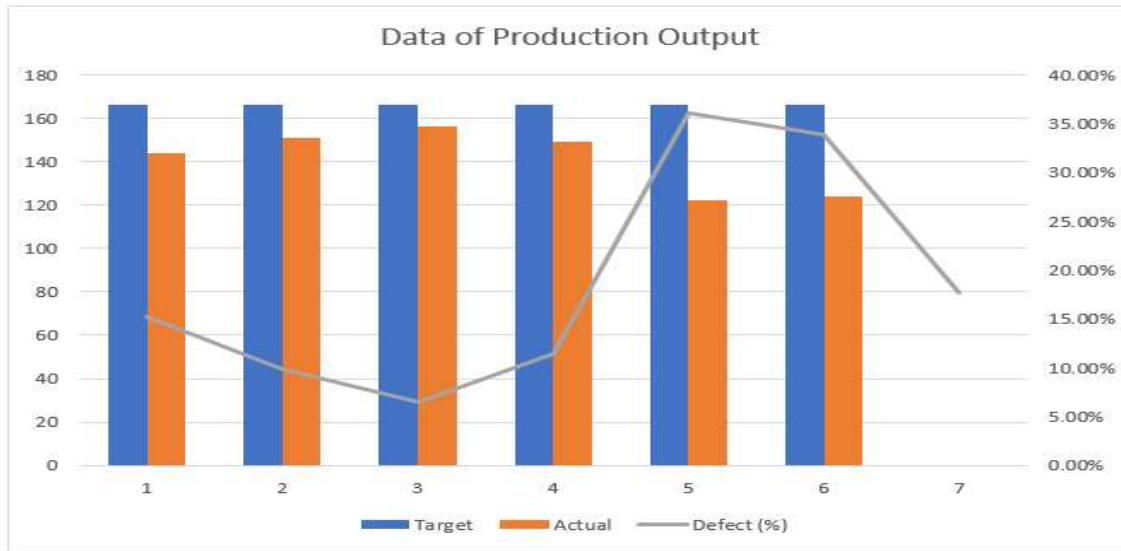


Figure 1. Data of Production Output of Item "Z"

this product is that the production target for this item has never been met. For instance, the production data for this item in order #996 was produced in 6 consecutive days, as shown in Figure 1.

From Figure 1, the target of the production output can not be achieved in the observed production period, and further, the trend of the achievement is declining. It might be caused by the inclining uptrend of the percentage of the defect of the item "Z."

The main research question is, what is the more cost-effective mitigation strategy to reduce the defect of the product "Z" based on the risk management approach under the proposed method in this research and the sample of production data of this product.?

## II. RESEARCH METHOD

In general, the are three main steps done to accomplish this research are detailed and elaborated as the following:

### 1. Research Preparation

In this stage, a preliminary observation is conducted to select the product to observe. The result, product "Z" is selected as the product for this project. Further, a both deductive and inductive study is performed to develop a firm problem statement and

originality of this research. Then, instruments to perform the analysis are prepared, such as: developing a research plan, making the list of questions to the participants, and selecting the participants. The participants in this research are eleven workers and their manager.

### 2. Data Collection

After step 1 is completed, the data collection step is conducted. In this stage, the activities are: collecting the data of likelihood dan impact of the risk, determining the financial cost of the risk, determining financial consequences for any mitigation, and the root cause. The data collection process includes brainstorming and questionnaire to select potential causes, interview, and Focus Group Discussion to determine the financial aspect of the risk mitigation

### 3. Data Processing and Analysis

After the required data to analyze the risk have been collected, it should be presented into a risk map and develop the root cause into the fishbone diagram. Financial analysis is also performed to determine which policy should be taken: leave the risk as it is or do the proposed mitigation action.

The detailed process of this research in the flow diagram is shown in Figure 2.

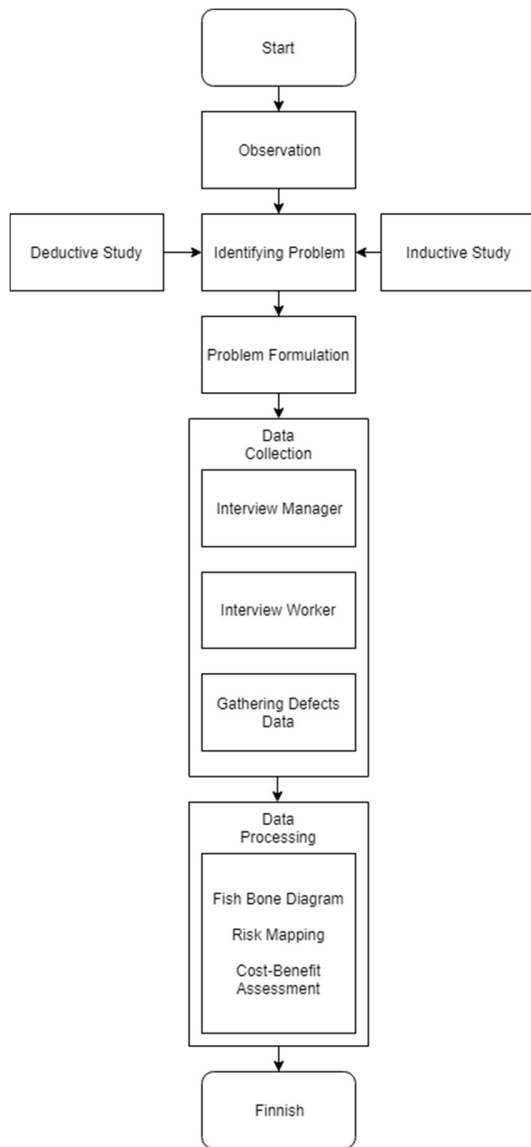


Figure 2. The flow of the Research steps

In the data processing step, a process of cost-benefit assessment is conducted. In this step, several cost equations will be developed to serve the operation of the cost analysis. The equations include the equation to calculate the total cost for each mitigation strategy as well as the detail of the cost equation consist of the cost elements. The propose of developing the cost equation is to be the basis of the cost analysis process. The equations are then verified into the case study. Also, in circumstances when the case study becomes more complex, the cost equations

can be extended to adapt to the complexity of the case study.

### III. RESULT AND DISCUSSION

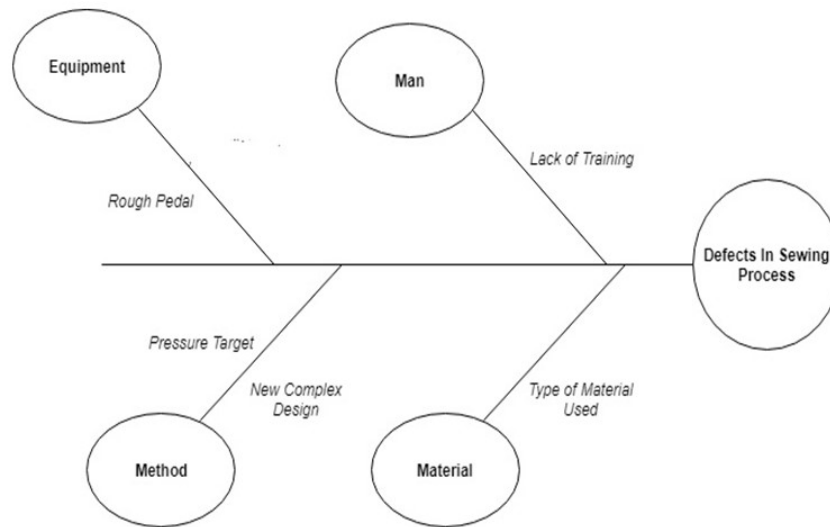
#### The Result

In this section, the result of this result is presented and analyzed. As aforementioned that this focus of this research in risk analysis on a defect of product Z. Firstly, the cause of the error is determined based on the answer to the questionnaire filled by the workers and the brainstorming. Briefly, 5 of 16 potential causes are selected as the primary causes. Those five significant causes are new complex design (C1), lack of training (C2), rough pedal (foot pedal on the machine) (C3), type of material used (C4), and target pressure (C5). For the convenience of the further discussion, initial C1 to C5 are used to represent each significant cause. Those five major causes can be presented in a fishbone diagram, as shown in Figure 3.

The fishbone diagram in Figure 3 shows the causes of the defect for the product "Z." The category of the causes is divided into four categories: Method, Material, Man, and Equipment. Those five significant causes are then plotted into the fishbone diagram, as shown in Figure 3. Briefly, the C1 is categorized into a method category as well as C5. In category Man, Equipment, and Material, the cause plotted is lack of training, rough pedal, and type of material used, respectively.

For the following process, it is necessary to prioritize the cause of the defect so that the most important cause can be mitigated first. The proposed tool to prioritize the purpose is the risk map. First, those five causes are transformed into a risk map. But before doing the risk mapping, it is crucial to determine the rubric for likelihood, severity, and financial criteria for the risk map. The three pieces of information are collected based on the interview and discussion with the manager. The rubric for likelihood, severity, and risk map criteria are presented in Tabel 1 to 3, respectively.

In this case study, the risk analysis is slightly different. Usually, the risks are placed in the risk



**Figure 3.** Fishbone Diagram for defect of Product 'Z.'

**Table 1.** Rubric for Likelihood

Parameter of Likelihood	Definition
Improbable	1 So unlikely, it can be assumed occurrence may not be experienced
Remote	2 Unlikely, but possible to occur
Occasional	3 Likely to occur sometime in the life of an item
Probable	4 Will occur several times in the life of an item
Frequent	5 Likely to occur frequently

**Table 2.** Rubric for Severity

Financial Loss	Severity Level
\$0 - \$ 50 (Rp 0 - Rp 705.700)	1
> = \$51 - \$100 (> Rp 719.814 - Rp 1.411.400)	2
\$101 - \$200 (> Rp 1.425.514 - Rp 2.822.800)	3
> = 201 - \$ 400 (> Rp 2.836.914 - Rp 5.645.600)	4
> = \$ 401 (> = Rp 5,659,714)	5

**Table 3.** Total Financial Loss for Risk Map

Total Financial Loss	Status in Risk Map
< 25 Million Rupiah	Low
< 50 Million Rupiah	Medium
< 75 Million Rupiah	High
> 75 Million Rupiah	Extreme

map, but in here the map contains the causes of the risk. The developed risk map based on the The result of the FGD associated with Table 1 to 3

is shown in Figure 4.

According to the result of the risk mapping, the cause to be the highest priority to mitigate is C4, followed by C2 and C5, and the least priority is C3 and C1. To further analyze the C4, another interview is conducted. The result indicates that the quality of the raw material influences the number of defects. For the product "Z," there are several alternatives to the material used instead of the current material used. However, some of the alternatives are more expensive than the current. At this stage, it is important to select the alternative material that may reduce the defect. The process of choosing the right raw material may lead to a conflicting situation, as suggested by Sherwin et al. (2016) and Bergion et al. (2018). The contradictory position can be represented as follow:

(S1) : *The higher grade of the raw material is selected. It may reduce the defect and*

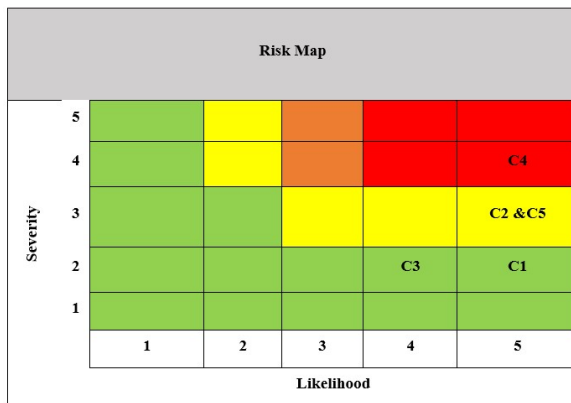


Figure 4. Risk Map of the Causes

leads to the reduction of the defect cost, but the raw material cost may hike.

(S2) : The current raw material is selected. It may save the material cost compared to S1, but the defect cost could be higher than S1.

In other words, S1 is the proposed mitigation to solve the cause C4, and S2 is the do-nothing strategy or leave the risk as it is. In this different situation, the decision-maker should seek the best alternative in terms of other options with the organization's least cost.

**Discussion and Cost Analysis**

Several pieces of research on the cost of mitigation and cost-benefit analysis on risk mitigation are analyzed, such as research by Bergion et al. (2018); Singh (2017); Sherwin et al. (2016); and Gillich, Brodecki, and Hufendiek (2019). From this research, Gillich et al. (2019) and Sherwin et al. (2016) do not present or explicitly develop a mathematical model for the cost analysis. While in Singh (2017), the general cost-effectiveness ration is used and as well as in Bergion et al. (2018), who use general cost-benefit equations and mathematical models to calculate the Net Present Value of the cost-benefit analysis. In this paper, several equations for cost analysis are proposed.

In this section, the analysis of mitigation costs is conducted. The cost elements included in the cost assessment are categories to fixed cost and variable cost within the production process at the sewing area only. The goal of this assessment is to ensure the decision-maker on

the alternatives of the mitigation strategies being compared based on the financial impact for each strategy. Briefly, a cost analysis is conducted to compare the cost generated from both Strategy 1 (S1) or Strategy 2 (S2). In this case study, the price for each raw material is confidential information. So that in the cost analysis, the raw material's valuation is assumed to be similar, and the study only includes the assessment on defect cost, overtime cost, and replacement cost.

A simple mathematical model is proposed to represent the process of cost analysis. As aforementioned, the cost analysis includes defect cost, overtime cost, and replacement cost, then the cost equation to calculate the mitigation cost is shown in Eq. 1.

$$T_C = C_D + C_R + C_O \quad \dots (1)$$

Where:

- $T_C$  : Total cost
- $C_D$  : Defect cost
- $C_R$  : Repair cost
- $C_O$  : Overtime cost

The detailed equations for each cost element,  $C_D$ ,  $C_R$ , and  $C_O$  are shown in Eq. 2, Eq. 3, and Eq. 4, respectively.

$$C_D = N_D \cdot P_S \quad \dots (2)$$

$$C_R = N_R \cdot C_P \quad \dots (3)$$

$$C_O = C_L \cdot H_O \quad \dots (4)$$

Where:

- $N_D$  : Number of defects
- $P_S$  : Selling price
- $N_R$  : Products to replaced
- $C_P$  : Production cost
- $C_L$  : Overtime labour cost
- $H_O$  : hours required for overtime

They are associating Eq. 2, Eq. 3, and Eq. 4 into Eq. 1 produces an equation for the total cost of mitigation as in Eq. 5.

$$T_C = (N_D \cdot P_S) + (N_R \cdot C_P) + (C_L \cdot H_O) \quad (5)$$

Then, observation and calculation to find the financial impact of the two different situations are performed. The Result of the cost calculation is shown in Table 4.

The cost shown in Table 4 is the cost for each order (approximately weekly). It can be indicated that if Situation 1 (leave the risk as it is) is selected by the management, the cost generated is approximately IDR 4,371,656 and if

**Table 4.** The result of the cost analysis

Cost	Product Z	Product Replacement	Differences
Defect Cost	IDR 2.145.328,00	IDR 1.185.576,00	IDR 959.752,00
Overtime Cost	IDR 81.000,00	IDR 10.800,00	IDR 70.200,00
Replacement Cost	IDR 2.145.328,00	IDR 1.185.576,00	IDR 959.752,00
Total Cost	IDR 4.371.656,00	IDR 2.381.952,00	IDR 1.989.704,00

the management selects S2 (the proposed Mitigation strategy) the potential cost is approximately IDR 2,381,952. It means that the proposed mitigation strategy generates less cost than the current situation. If the management select to mitigate the risk as proposed, it is predicted that the company may save approximately IDR 1,989,704 per order made. The saving mostly comes from the reduction of defect cost and overtime cost. Once again, it should be noted that this cost analysis has not included the cost of material yet.

In S1, the material used in the current situation is cheaper than the material proposed in S2. Since the information on the price of both materials is confidential, the calculation could not directly include in the cost analysis. In the case that the price of both the material is significantly different, the price of the material should be associated with the cost calculation. Another equation is proposed to consider this circumstance, as shown in Eq. 6.

$$I = \Delta T_c - \Delta C_M \quad \dots (6)$$

$$\Delta T_c = T_{CR} - T_{CM} \quad \dots (7)$$

$$\Delta C_M = C_{MR} - C_{MM} \quad \dots (8)$$

Where:

I : Cost comparison index

$\Delta T_c$  : The difference of total cost of two strategies

$\Delta C_M$  : Cost difference from two different raw material

$T_{CR}$  : Total cost of the S1

$T_{CM}$  : Total cost of the S2

$C_{MR}$  : Cost of the raw material from S1

$C_{MM}$  : Cost of the raw material from S2

The result of the Eq. 6 is an index, and the value could be positive, null, or negative. If the index is positive, it means that the proposed strategy generates less cost than the current policy. Oppositely, if the index is negative, the current policy is financially more feasible than the

proposed strategy. If the value of the index is null, the management can choose either a contemporary or proposed strategy because the financial impact is relatively similar. In the financial analysis, it is argued that engineering economics can be associated as well as in Singh (2017) and Bergion et al. (2018).

#### IV. CONCLUSION

In this research, a cost analysis is associated with the risk mitigation process to provide a more comprehensive recommendation to select the mitigation strategy. The cost analysis is successfully injected into the mitigation process. The process begins when the risk analysis starts with determining the most potential risk to solve. In this case, the risk of a product defect is selected. Then, the major causes of the product defect are determined and prioritized using the risk map. The result is a mitigation strategy. Then, the mitigation strategy is analyzed base on the cost generated and compared to the cost generated if the risk is left as it is. Several equations are developed and applied to the case study to serve the cost analysis. The result is the proposed mitigations strategy generates less cost than the current (leave the risk as it is – the do-nothing strategy).

For further research, the process of associating the cost analysis into the risk management process can be combined with the lean process. In other words, the wastes in the lean concept can serve as potential risks. The consequences of this concept, a more complex cost equation can be developed. They should be able to cover all costs generated by the mitigation process policy or the waste reduction process. Then, the cost analysis can be done to determine whether the waste reduction program may save costs or generate more cost instead. In

this term, the financial feasibility of the mitigation strategy is assessed. Engineering economics analysis with Net Present Value can also be used to make the cost analysis more thorough.

### ACKNOWLEDGMENT

The authors would like to thank the Department of Industrial Engineering and The Faculty of Industrial Technology, Universitas Islam Indonesia, for the support to accomplish this research.

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