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Calculation of Copper Production Failure Risk Level Based on Aggregate Loss Cost

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Abstract

In its implementation, the copper manufacturing industry often faces various risks, one of which is the risk of production failure. This research aims to calculate the level of risk of factory failure in producing copper based on aggregate loss costs. Quantitative methods were used in this research. It calculates the failure frequency, which follows a Poisson distribution, the loss distribution, which follows an exponential distribution function, and the total loss amount.

Key words: Copper manufacturing industry, production failure, aggregate loss costs.

1. Introduction

The copper manufacturing industry plays an important role in the global economy (Haryanti, A.D., 2019). However, this industry also faces various risks, one of which is the risk of production failure. Production failures can be caused by various factors, including raw material supply disruptions, machine failure, human error, or even natural disasters. These risks can negatively impact business operations, resulting in shipping delays, increased costs, and reduced product quality. In addition, production failures can have a significant impact on the aggregate loss costs that must be borne by the company (Fawzuna, 2020). Therefore, this study aims to calculate the level of risk of factory failure in producing copper based on aggregate loss costs. This research is expected to provide a better understanding of how the risk of production failure can affect aggregate loss costs. In this way, companies can make better and strategic decisions in their operations, thereby increasing production efficiency and effectiveness. It is hoped that the results of this research can be a reference for the copper manufacturing industry and other industries in managing the risk of production failure and its impact on aggregate loss costs. Apart from that, this research is also expected to contribute to academic literature in the fields of risk management and production management.

2. Literature Review

In this research, the author used previous research as a reference. The research journal used as a reference is "Calculation of Cyber Risk Levels in Digital Financial Services Based on Aggregate Loss Costs" with the authors being Putri Chaerunnisa Febryanti, Betty Subartini, and Riaman. In this journal, the object used as research is the level of cyber risk based on the history of FinTech company service losses calculated from the number of cyber attack incidents before the Covid-19 pandemic. The aim of this research is to estimate the level of cyber risk by taking into account the aggregate loss costs in digital financial services based on an operational model that has the aim of minimizing required capital (Hammad, 2020). This research uses a quantitative approach by calculating the frequency of cyber attacks that follow a Poisson distribution, loss distribution that follows an exponential distribution function, and calculating the size of aggregate losses. The results of this research are that the Poisson distribution and exponential distribution can be used to measure cyber risk based on aggregate losses. If it is related to the research that will be carried out by the author with the title "Calculation of the Risk Level of Copper Production Failure Based on Aggregate Loss Costs", then the research that has been carried out by Putri Chaerunnisa Febryanti, Betty Subartini, and Riaman has differences, namely in the objects used.

3. Materials and Methods

3.1. Materials

The data used in this research is data on costs and losses owned by factories that produce copper. This data is daily data for 19 months, namely from January 4 2021 to July 30 2022. In this data, there is information on loss costs, repair time, production per day, income per day, and total costs and losses. This data is secondary data obtained through the Kaggle site.

3.2. Methods

3.2.1. Random Variable

A random variable is a variable whose value is determined randomly. Random variables consist of discrete random variables and continuous random variables. A discrete random variable is a random variable that if its space is limited or can be counted (Song, 2022). Suppose X it is a discrete random variable with space S, the probability density X function is:

$$p_x(x) = P(X = x), x \in S \tag{1}$$

and satisfies the following two properties of equality:

$$\sum_{i=1}^{n} p_{x_i}(x_i) = 1 \ dan\ 0 \leq p_x(x) \leq 1 \tag{2}$$

Furthermore, a continuous random variable is a random variable that produces all values on a continuous scale (Pratikno et al., 2020). The probability density function on a continuous random variable satisfies the following equation:

$$F(x) \geq 0\ \forall x \in R \tag{3}$$

$$\int_{-\infty}^{\infty} f(x)dx = 1 \tag{4}$$

$$P(a < X < b) = \int_{-\infty}^{\infty} f(x)dx \tag{5}$$

3.2.2. Poisson distribution

Poisson distribution theory refers to the number of events that occur at a certain time or area. Poisson has characteristics, namely that the random variables are discrete and the data is related to the magnitude of the average value - the average value of a certain situation in a certain period of time (μ). Inouye, (2017) states that the equation of Equation shows a Poisson distribution. the following:

$$P(X = x) = \frac{\mu^x e^{-\mu}}{x!}, untuk\ x = 0,1,2, \ldots \tag{6}$$

with:
x: whole number
e: exponential number = 2.718281...
μ: the average of an event in a certain time interval

The expectation and variance of the Poisson distribution are as follows:

$$E[X] = \mu \tag{7}$$

$$Var[X] = \mu \tag{8}$$

3.2.3. Exponential Distribution

According to Inouye, (2017), the exponential distribution shows the probability of waiting time between events in a Poisson distribution. The distribution of a continuous random variable X is exponential with parameter λ greater than 0, if it has the following distribution capabilities:

$$f(x) = \begin{cases} \lambda e^{-\lambda x}, x > 0 \\ 0, x\ lainnya \end{cases} \tag{9}$$

with s$\lambda = \frac{1}{\mu}$: exponential distribution scale parameter

Cumulative distribution function:

$$F(X:\lambda) = 1 - e^{-\lambda x} \tag{10}$$

The expectation and variance of the exponential distribution are:

$$E(x) = \frac{1}{\lambda} \tag{11}$$

$$Var(x) = \frac{1}{\lambda^2} \tag{12}$$

3.2.4. Chi-Square Test Procedure

A continuous random variable that corresponds to items or responses that can be divided into different categories is called Chi-Square. The purpose of the Chi-Square test method is to determine whether there is a significant difference between the number of objects observed or the specific reaction of each classification to the expected value based on the null hypothesis. The chi-square test process is described as follows by Allen (2009):

a. Determine the hypothesis formulation
   H_0: the model being tested follows a certain distribution
   H_1: the model being tested follows another distribution
b. Determine the level of significance and value by calculating the degrees of freedom using the formula$(\alpha)\chi^2 n - k - 1$
c. Determining table values refers to the Chi-Square table
d. Determine the statistical test value using the equation:

$$\chi^2 = \sum_{i=o}^{n} \left[\frac{(O_i - E_i)^2}{E_i} \right] \tag{13}$$

with:

O_i: observation value obtained in the i category
E_i: expected value in the i-th category

3.2.5. Data Analysis Stages

a. Collecting copper production data collected on the Kaggle site from January 4 2021 to July 30 2022.
b. Make model assumptions for the frequency of failure events in copper production.
c. Make model assumptions and calculate loss distribution using the exponential distribution function.
d. Test the suitability of the model using the chi-square test as in equation (13) with the help of the Microsoft Excel application.
e. Create a model for aggregate loss distribution.
f. Calculates the probability of the frequency of events using generated random numbers generated through the R Studio application with the syntax rpois () by stating the number of random numbers generated and is the Poisson parameter.$n, \mu n \mu$
g. Calculates the probability of loss distribution using uniform random numbers generated through the R Studio application with runif () syntax by stating the number of random numbers generated, is the minimum random number, and is the maximum random number.$n, min = x, min = ynxy$
h. Carry out simulations 1000 times.
i. Sort losses from largest to smallest.
j. Determine the risk based on the largest loss.

4. Results and Discussion

4.1 Assumptions of the Frequency of Event Model

The copper production failure frequency model is analyzed per month. Frequencies are assumed to follow a Poisson distribution. The probability x of a production failure event is expressed in the function:

$$P(x_i) = \frac{\mu^{x_i} e^{-\mu}}{x_i!} \tag{14}$$

with:

μ: the average copper production failure event for 19 months, namely 7.58.

x_i: the possibility of copper production failure per month, with$i = 0,1,2, \ldots ,10$
e: exponential number = 2.718281…

4.2 Loss Distribution Model Assumptions

The loss frequency distribution model is assumed to follow an exponential distribution. The loss distribution is expressed in the function:

$$q(x) = \lambda e^{-\lambda x} \tag{15}$$

Cumulative distribution:

$$Q(x;\lambda) = 1 - e^{\lambda x} \tag{16}$$

with:
$\lambda = \frac{1}{\mu} = \frac{1}{7,58} = 0,13$: scale parameter for the 19-month average of copper production failure events
x: the magnitude of the distribution of losses from events that occur
e: exponential number = 2.718281…

4.3 Aggregate Loss Distribution Model

Based on model assumptions and goodness-of-fit tests, parameters (μ) and (λ) parameter are obtained. These parameters will be used in calculating the aggregate loss distribution by combining the two distributions to form an aggregate loss distribution that has a Poisson or exponential distribution. The total loss is:

$$f((K_x, L_x) = \frac{e^{-\lambda}\mu^{K_x}}{K_x!} + \lambda e^{-\lambda L_x} \tag{17}$$

with:
μ: average copper production failure per month.
K_x: the number of failures that occur
L_x: the magnitude of the loss distribution
λ: scale parameter for loss distribution

4.4 Simulation of Aggregate Loss Cost Calculation

1. Calculate the average amount of loss (μ) based on the average number of failure events obtained $\lambda = 0,13$
2.The frequency of events follows a Poisson distribution and the loss distribution follows an exponential distribution
3.Using the data parameters of the average frequency of the Poisson distribution and the average loss of the exponential distribution, a simulation was carried out using Poisson parameters (□=7.58) and exponential scale parameters (□=0.13).
4. Generate random numbers that indicate the number of attacks that have occurred and the distribution of losses.

5. Conclusion

This study identifies and quantifies the risk of production failure in the copper manufacturing industry using quantitative methods. In this study, the frequency of production failures is calculated based on the Poisson distribution, while the loss distribution follows the exponential distribution function. The research also calculates the total amount of loss caused by these failures. The results provide an overview of the plant's failure risk level in producing copper based on the aggregate loss cost.

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