Assessing financial risks at PT Pertamina: insights from Monte Carlo and Altman Z-score

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Abstract
The COVID-19 pandemic caused a significant drop in fuel demand and supply, with PT Pertamina's oil prices falling to USD 20 per barrel in 2020. In light of this situation, this study analyzes PT Pertamina's financial risk management from 2012 to 2023, using Monte Carlo simulations, sensitivity analysis, and regression models to evaluate the impact of various risks on financial indicators such as total revenue, ROA, ROE, NPM, and EBIT. The Monte Carlo simulation showed considerable fluctuations in net profit due to oil price volatility and exchange rate changes. Sensitivity analysis identified operational risks as critical to financial sustainability, while market risks were positive under specific conditions. Regression analysis indicated that exchange rate fluctuations significantly impacted Total Revenue, but oil prices had minimal effect on ROA and ROE. The Altman Z-Score analysis revealed a declining financial health trend, especially between 2016 and 2020, with an increased bankruptcy risk. While PT Pertamina saw recovery in 2021-2023, it remains in a high-risk zone, requiring strategic measures such as business diversification, supply chain optimization, and proactive exchange rate policies to ensure long-term stability.

Keywords: *financial performance, risk management, sensitivity analysis, OLS Regression*

Introduction

Oil is one of the most important commodities in the world, which plays a very important role in supporting various economic activities in all industrial sectors (Ma et al., 2018; He et al., 2019; Roh et al., 2021). As a key component in the production of goods and services, fluctuations in the price and availability of oil have a direct impact on global economic stability. This was especially evident during the global recession triggered by the COVID-19 pandemic, which affected almost all sectors of the economy, including the oil and gas industry (Altig et al., 2020; Salisu et al., 2022). The importance of financial risk analysis in the oil industry cannot be ignored, as these risks affect the overall financial performance of the company. Such financial risks include operational risk, market risk, credit risk, and liquidity risk, each of which has a potentially significant impact on the company's financial stability. In this study, PT Pertamina's annual report is used as an important source of data to identify the risk factors faced by the company.

Research by Azra et al. (2022) discusses the analysis of the financial performance of PT Pertamina based on serial index analysis. Other research by Murtiningrum (2022) using PT Pertamina data for further financial ratio analysis. Although these studies used data from PT Pertamina, there are still few studies that focus on financial risk management strategies specific to PT Pertamina. Moreover, the COVID-19 pandemic has put enormous pressure on the oil industry, with restrictions on public activities and decreased use of transportation globally resulting in significant disruptions to the demand and supply of fuel oil (BBM). This impact can be seen in PT Pertamina's drastic drop in oil prices to USD 20 per barrel in 2020.

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(Pertamina, 2020). This research aims to provide guidance for relevant management in identifying, analyzing, and managing the financial risks faced with the aim of implementing effective risk management strategies to improve financial performance and support the long-term sustainability of the company. The method chosen in this study is based on its relevance and excellence in addressing aspects of financial risk. The selection of these methods is supported by evidence of success in previous studies and suitability to the research objectives. Several methods were used to look at the financial performance of PT Pertamina.

This research uses a complete approach to identify and analyze the financial risks of PT Pertamina. Monte Carlo Simulation and Altman Z-Score methods were used to forecast long-term financial conditions. In Bocanegara and team's research, they used the *Monte Carlo* simulation method to model financial risk. This method involves using random variables to identify and determine the likelihood of various outcomes in a financial model. Bocanegra et al. (2024) Monte Carlo simulation helps project changes in net income, while Altman Z-Score is used to measure the likelihood of the company's bankruptcy risk in the next five years. Likewise, previous research by Dian and team applied *Altman Z-Score* to assess bankruptcy risk which can provide an early indication of the company's potential bankruptcy risk (Dian & Gunawan Putri, 2021). In addition, sensitivity analysis is applied to determine the factors that affect cash flow such as El-Temtamy and team's research proving the importance of sensitivity analysis to understand how changes in external variables, such as oil prices and currency exchange rates can affect financial performance El-Temtamy & Gunawan Putri, 2021; El-Temtamy & Gendy, 2014). Another study by Ramdhani and team highlighted the importance of cash flow analysis to understand liquidity and solvency (Ramdhani & Elmanizar, 2014). Ramdhani and Elmanizar (2019) Ordinary Least Squares (OLS) regression is used to see the relationship between important variables that affect finance. Eirene stated in her research that using the *Ordinary Least Squares* (OLS) method can help in understanding how several variables can statistically affect financial performance. (Eirene & Andrayani, 2018).

ANOVA methods, both One-Way and Two-Way, are used to compare financial performance based on different risk groups. The combination of these methods provides a clear picture of financial risks and offers strategies to maintain the stability and sustainability of the company. Furthermore, significant differences in 1 particular variable were tested using One-Way ANOVA. The use of One-Way ANOVA was chosen because this method allows comparison of the averages of several groups based on one independent factor. Basuki (2015) One of them is the level of risk to financial performance, so it is efficient and reduces the risk of error (Li, 2023). Meanwhile, Two-Way ANOVA is used to analyze two factors (Rodrigues et al., 2024). Palacin and team's research conducted ANOVA tests to identify significant differences in financial performance based on various risk factors (Lim et al., 2023).

This research is important for the identification and proper management of financial risks, which not only help companies maintain financial stability but also maximize contributions to the national economy (Eng & Vichitsarawong, 2022). This research targets the main outcome of identifying significant financial risks faced by PT Pertamina through analyzing their impact on company performance, as well as recommendations for risk management strategies that can be implemented to strengthen the stability and sustainability of the company.

Methods

The research flowchart can be seen in Figure 1. The research begins with data collection related to Pertamina's financial condition. After the data is collected, pre-processing is carried out to ensure data quality, with steps such as data cleaning, normalization, and transformation

so that it is ready to be used in further analysis. The determining variables used in this study include total revenue, Return on Assessment (ROA), Return on Equipment (ROE), Earnings Before Interest and Taxes (EBIT), and Net Profit Margin (NPM). Umma and her team stated that financial ratios such as ROE can provide an overview of the company's financial health (Atul et al., 2022). Total revenue was chosen as the determining variable used to measure the company's total revenue, as in Buyue and team's research, which states that total revenue is used to predict financial risk in companies (Qian & Li, 2013). Abdul, in his research, uses ROA and NPM to measure the company's financial performance (Chadjib Halik, 2021). EBIT was also used in Li and team's research to predict future cash flows.

Some of the analytical methods used include sensitivity analysis to assess whether risk variables affect the Internal Rate of Return (IRR), Payback Period (PP), and Net Present Value (NPV). Then, linear regression using Ordinary Least Squares (OLS) was conducted to identify the relationship between risk and independent variables. In addition, the Altman Z-Score method was used to assess the risk of corporate bankruptcy, and ANOVA to analyze significant differences in financial performance from year to year. Finally, Monte Carlo simulation was used to predict the increase in operating costs and revenue of the company.

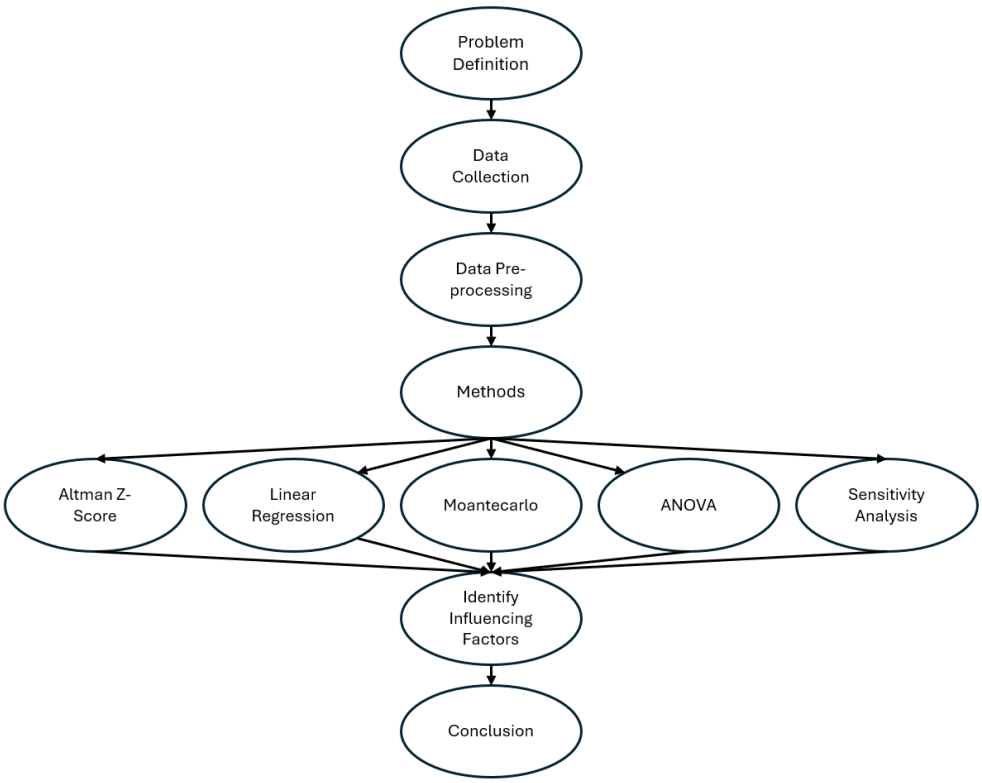


Figure 1. Research Framework

Results and Discussion

The data used in this analysis comes from PT Pertamina's annual financial statements for the period 2012-2023 taken directly from the company's official annual report (https://www.pertamina.com/id/dokumen/laporan-tahunan). In addition, data on the Rupiah exchange rate as a market risk is obtained from a trusted source, namely exchange-rates.org. The data is then classified into four risk categories, namely operational risk in the

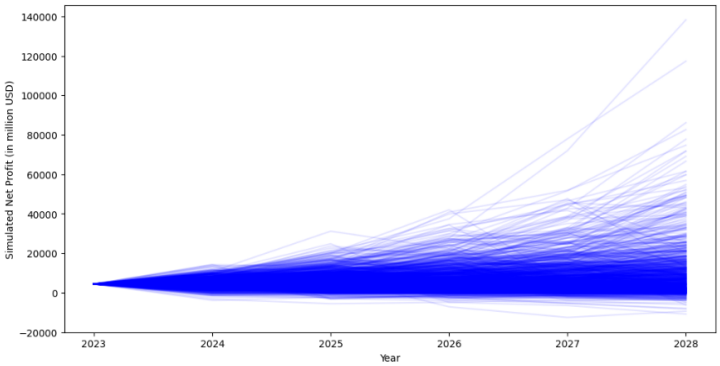
form of operating costs, market risk in the form of Rupiah exchange rates and oil prices, credit risk in the form of debt ratio, and liquidity risk in the form of current ratio and quick ratio. The main variables used in this study include Total Revenue, ROA, ROE, NPM, and EBIT. This study also adds additional variables used in the calculation of Altman Z-Score.

To ensure the accuracy and consistency of the data, validation was carried out by equating units (if not in percent) to millions, as well as cross-checking between sources and logical validation. Data obtained from annual reports and exchange-rates.org were then adjusted to ensure that all variables measured what they were supposed to measure. With these steps, we ensure that the data used in this study has high integrity and can be relied upon to produce valid findings. A summary of the input data is presented in Table 1.

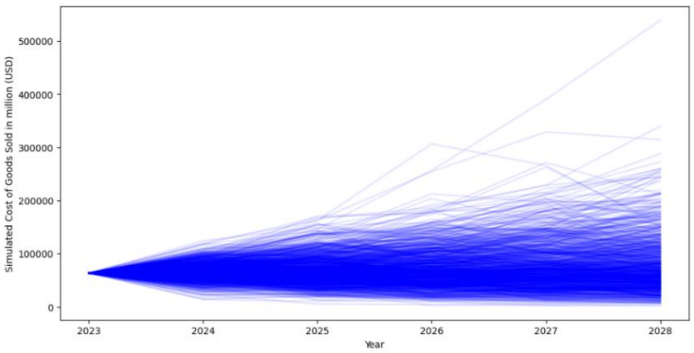
Table 1. Data variables used Data variables used

Index	Category	Variables	Unit	Source
-	-	Net Profit	Million USD	Annual Report
X_{1-1}	Operational Risk	Cost of Goods Sold	Million USD	Annual Report
X_{2-1}	Market Risk	Rupiah Exchange Rate	Million USD	External
X_{2-2}	Market Risk	Oil Price	Million USD	Annual Report
X_{3-1}	Credit Risk	Department Ratio	Percent (%)	Self Calculation
X_{4-1}	Liquidity Risk	Current Ratio	Percent (%)	Annual Report
X_{4-2}	Liquidity Risk	Quick Ratio	Percent (%)	Self Calculation
Y_1	Measurement Variable	Total Revenue	Million USD	Annual Report
Y_2	Measurement Variable	ROA	Percent (%)	Self Calculation
Y_3	Measurement Variable	ROE	Percent (%)	Annual Report
Y_4	Measurement Variable	Net Proft Margin	Percent (%)	Self Calculation
Y_5	Measurement Variable	EBIT	Million USD	Annual Report
X_1	Additional Variables	Working capital	Million USD	Annual Report
X_2	Additional Variables	Profit Balance	Million USD	Annual Report
X_3	Additional Variables	EBIT	Million USD	Annual Report
X_4	Additional Variables	Market Value of Equity	Million USD	Annual Report
X_5	Additional Variables	Liabilities	Million USD	Annual Report
-	Additional Variables	Assets	Million USD	Annual Report
		Net Profit	Million USD	Annual Report

Monte Carlo simulation is a statistical method used to model and analyze uncertainty in PT Pertamina's financial projections. This method allows the assessment of various possible financial outcomes using random variables, thus providing a more realistic picture of the risks and potential future performance of the company (Zalmadani et al., 2020). In this study, Monte Carlo simulation is applied to predict PT Pertamina's net profit and Cost of Goods Sold (COGS) from 2023 to 2028.



(a)



(b)

Figure 2. Monte Carlo Visualization of (a) Future Net Profit and (b) Cost of Goods Manufactured

In the future net profit projection in Figure 2(a), the simulation results show that PT Pertamina faces significant uncertainty over the next five years. Most scenarios indicate a potential increase in profits, reflecting optimism about the company's growth strategy and favorable market potential. However, there are also scenarios that indicate a decline or stagnation of profits, which may be caused by external factors such as a decline in global oil prices or unexpected fluctuations in the rupiah exchange rate. Causal mechanisms that affect net profit include oil price volatility, fluctuations in the rupiah exchange rate, and global economic conditions. Oil price volatility directly affects revenue from oil sales; a decrease in oil prices can reduce revenue and net profit, while an increase in oil prices can increase revenue and net profit provided production costs are kept under control. Fluctuations in the rupiah exchange rate also play an important role; an appreciation of the rupiah can reduce raw material import costs, increasing profit margins and net profit, while a depreciation of the rupiah can increase import costs and reduce net profit if revenues cannot be adjusted proportionally. In addition, global economic conditions such as recession or slow economic growth may reduce the demand for oil, negatively impacting PT Pertamina's overall revenue. The practical implications of these simulation results suggest that in order to optimize potential net profit growth, PT Pertamina needs to diversify its portfolio by investing more in renewable energy to reduce dependency on oil prices. In addition, hedging strategies through the use of financial instruments such as forward contracts or options can protect earnings from fluctuations in the rupiah exchange rate and oil prices. Operational efficiency also needs to be improved by optimizing production costs through advanced technology and efficient supply chain management.

In the Cost of Goods Sold (COGS) projection in Figure 2(b), the simulation shows that PT Pertamina's COGS has the potential to increase significantly in some scenarios, especially if the price of raw materials such as oil continues to fluctuate. This increase in COGS may reduce profit margins and squeeze net profit, especially if the company is unable to adjust selling prices effectively. Causal mechanisms affecting COGS include raw material prices, supply chain efficiency, and long-term contracts. Rising oil prices will increase production costs and COGS, while a lack of efficiency in the supply chain may lead to higher operating costs. In addition, reliance on inflexible long-term contracts may make PT Pertamina vulnerable to raw material price increases. To manage the risk of rising COGS, PT Pertamina needs to optimize its supply chain by adopting advanced technology and efficient management strategies to reduce

operating costs. Establishing long-term contracts with suppliers is also important to secure more stable raw material prices. In addition, the implementation of cost control programs should be undertaken to ensure that increases in production costs do not significantly reduce the company's profit margins.

The Monte Carlo simulation results are consistent with the literature that emphasizes the importance of external risk management in the energy industry. This study reinforces the understanding that oil price volatility and fluctuations in the rupiah exchange rate are the main factors affecting the financial performance of companies in the oil and gas sector. In addition, this study adds a new contribution by showing how a combination of operational and liquidity risks can affect the financial viability of projects through probabilistic simulations.

Sensitivity analysis is a "what-if" technique used to evaluate how changes in key variables affect key project performance indicators, such as Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (PP). Sensitivity analysis is usually conducted before a decision is made(DIMAS BAGUS SATRIYO WIBOWO, 2020).In the context of this study, sensitivity analysis was conducted to assess the impact of changes in risk variables (Cost of Goods Sold, Rupiah Exchange Rate, Oil Price, Dept Ratio, Current Ratio, and Quick Ratio) on PT Pertamina's financial performance. The following are the results and in-depth interpretation of the sensitivity analysis that has been conducted.

Table 2. Sensitivity Analysis Results

Influence Variable	NPV	IRR	PP
	1910.87	12.41%	7.28 years
X_{1-1}	-354348.19	nan%	Not achieved
X_{2-1}	1910.87	12.41%	7.28 years
X_{2-2}	1910.87	12.41%	7.28 years
X_{3-1}	1534.97	11.94%	7.42 years
X_{4-1}	717.05	10.92%	7.72 years
X_{4-2}	1089.40	11.39%	7.56 years

The results of the sensitivity analysis show how changes in each risk variable affect the financial viability of the PT Pertamina project. Before incorporating the risk variables, the project showed a positive NPV of USD 1,910.87 million, IRR of 12.41%, and PP of 7.28 years, indicating good investment feasibility. However, after incorporating risk variables, the impact on the project's financial performance indicators varies. The operational risk represented by Cost of Goods Sold (X_{1-1}) drastically reduces the NPV to a negative -354,348.19 million USD, making the IRR unachievable (nan%) and PP unachievable as well. This shows that an increase in operational costs can make the project financially unviable, so PT Pertamina needs to optimize operational costs to maintain project viability.

On the other hand, market risks represented by Rupiah Exchange Rate (X_{2-1}) and Oil Price (X_{2-2}) do not significantly affect the investment feasibility of the project in this scenario. NPV remains positive at USD 1,910.87 million, IRR at 12.41%, and PP at 7.28 years. Although fluctuations in the rupiah exchange rate and oil prices can affect revenues and costs, PT Pertamina managed to keep the project's financial performance positive through effective risk management strategies. Credit risk as measured by Debt Ratio (X_{3-1}) still maintains a positive NPV of USD 1,534.97 million. However, the IRR slightly decreased to 11.94% and PP increased to 7.42 years, indicating that an increase in debt ratio lengthens the payback period and slightly decreases the rate of return on investment. Therefore, PT Pertamina needs to manage debt more efficiently to increase IRR and reduce PP.

In addition, liquidity risk measured through Current Ratio (X_{4-1}) and Quick Ratio (X_{4-2}) showed a decrease in NPV to USD 717.05 million and USD 1,089.40 million, respectively. IRR also decreased to 10.92% and 11.39%, while PP increased to 7.72 years and 7.56 years. This indicates that increased liquidity risk worsens the financial viability of the project by lowering the rate of return and extending the payback period. Therefore, PT Pertamina needs to improve liquidity management to maintain optimal project financial performance. The finding that operational and liquidity risks have a significant impact on financial performance is consistent with previous literature that emphasizes the importance of internal risk management in maintaining a company's financial stability (El-Temtamy & Gendy, 2014).

Based on the results of the sensitivity analysis, PT Pertamina needs to focus on managing operational and liquidity risks to maintain the financial viability of the project. Strategic recommendations include optimizing operational costs by implementing energy efficiency technologies and automating production processes to reduce Cost of Goods Sold, as well as improving supply chain management to control costs and reduce operational risks that may affect NPV and IRR. In addition, liquidity management should be strengthened by increasing cash and cash equivalents, and managing current assets more efficiently. The use of financial instruments such as short-term credit facilities can also help keep current and quick ratios stable. To mitigate credit risk, PT Pertamina needs to manage debt more efficiently to lower the Debt Ratio, thereby increasing IRR and lowering PP. In addition, improving the liquidity ratio will ensure the company's ability to fulfill its debt obligations.

Ordinary Least Square (OLS) regression was used to model the relationship between the independent variables (operational, market, credit, and liquidity risk) and the dependent variables (Total Revenue, ROA, ROE, NPM, and EBIT). After obtaining the regression coefficients, we tested the significance of each coefficient using the p-value (Gunandi, 2023) and conducted a multicollinearity test using the Variance Inflation Factor (VIF). Below are the results and more in-depth interpretation of the regression analysis. In the *Ordinary Least Square* (OLS) regression analysis, several variables are used that represent financial performance and external factors affecting the company. Total Revenue (Y_1), *Return on Assets* (Y_2), *Return on Equity* (Y_3), Net Income (Y_4), Earnings Before Interest and Taxes (Y_5), Cost of Goods Sold (X_{1-1}), *Dept* Ratio (X_{2-1}), Oil Price (X_{2-2}), Dept Ratio (X_{3-1}), Current Ratio (X_{4-1}), Quick Ratio (X_{4-2}).

The regression analysis results show that the rupiah exchange rate (X_{2-1}) has a significant positive effect on Total Revenue (Y_1) with a coefficient of 10.699 ($p < 0.001$). This indicates that the appreciation of the rupiah increases PT Pertamina's revenue through reduced import costs and increased purchasing power of domestic consumers. An increase in the rupiah exchange rate allows the company to import raw materials at a lower cost, which in turn increases profit margins and overall revenue. On the other hand, the Oil Price variable (X_{2-2}) shows a near significant effect on Return on Assets (ROA) (Y_2) and Return on Equity (ROE) (Y_3), with p-values of 0.059 and 0.053 respectively. Although not reaching the traditional level of significance ($p < 0.05$), these findings suggest that oil price volatility has a potentially significant impact on the profitability of a firm's assets and equity. Oil price volatility can directly affect PT Pertamina's revenue and operating expenses, which in turn impact ROA and ROE. Risk management through hedging strategies and portfolio diversification may have been implemented to mitigate the negative impact of oil price fluctuations, so that its effect on ROA and ROE becomes less statistically significant.

Table 3. Ordinary Least Squares Regression Results

Y	Methods	Cont.	X_{1-1}	X_{2-1}	X_{2-2}	X_{3-1}	X_{4-1}	X_{4-2}
Y_1	Coeff.	-2,03e+07	10.699	142.89	5.2e+07	684.88	270.05	943.50
Y_1	Std err.	1.4e+04	0.13	25.03	9.11e+07	186.09	109.63	98.53
Y_1	t-Stat.	-1.454	7.82	0.571	0.571	0.368	0.246	0.95
Y_1	P-value	0.196	0.00	0.58	0.58	0.72	0.81	0.37
Y_2	Coeff.	-2.72	-6.384e-05	0.024	8.913e+04	-0.020	0.05	-0.04
Y_2	Std err.	5.871	5.74e-05	0.011	3.83e+04	0.078	0.046	0.041
Y_2	t-Stat	-0.464	-1.111	2.328	2.328	-0.252	1.256	-1.059
Y_2	P-value	0.659	0.309	0.059	0.059	0.809	0.256	0.330
Y_3	Coeff.	5.008	-0.0002	0.105	3,82E+08	-0.359	0.195	-0.179
Y_3	Std err.	24.390	0.000	0.044	1.59e+05	0.325	0.191	0.172
Y_3	t-Stat.	0.205	-0.700	2.403	2.403	-1.106	1.018	-1.038
Y_3	P-value	0.844	0.510	0.053	0.053	0.311	0.348	0.339
Y_4	Coeff.	-3.936	-7.43e-05	0.019	6,99E+07	-0.028	0.056	-0.012
Y_4	Std err.	8.157	7.98e-05	0.015	5.32e+04	0.109	0.064	0.058
Y_4	t-Stat	-0.483	-0.931	1.314	1.314	-0.255	0.876	-0.213
Y_4	P-value	0.646	0.388	0.237	0.237	0.807	0.415	0.838
Y_5	Coeff.	-1.18e+04	0.097	-1.077	-3,92E+09	121.17	14.008	18.608
Y_5	Std err	8025.123	0.079	14.379	5.23e+07	106.88	62.972	56.594
Y_5	t-Stat.	-1.470	1.238	-0.075	-0.075	1.134	0.222	0.329
Y_5	P-value	0.192	0.262	0.943	0.943	0.300	0.831	0.753
	VIF	-	7.238	3.841	6.890	1.682	11.149	11.136

On the Net Profit Margin (Y_4) and EBIT (Y_5) variables, no significant effect of operational risk (X_{1-1}), market risk (X_{2-2}), credit risk (X_{3-1}), or liquidity (X_{4-1} and X_{4-2}) variables was found ($p > 0.05$). This can be explained by the effectiveness of internal management strategies implemented by PT Pertamina, such as optimizing operational costs and improving production efficiency, which successfully kept profit margins and EBIT stable despite facing various external risks. Multicollinearity analysis shows that the variables Rupiah Exchange Rate (X_{2-1}) and Quick Ratio (X_{4-2}) have a Variance Inflation Factor (VIF) of 7,238 and 11,136, respectively. These VIF values indicate the potential for multicollinearity, especially in the Quick Ratio (X_{4-2}) which exceeds the common limit (VIF < 10). Multicollinearity may affect the stability of the regression coefficients and reduce the reliability of the interpretation of the results.

The finding that the rupiah exchange rate has a significant impact on Total Revenue is consistent with previous studies that show the importance of exchange rate stability in the energy industry (Ramdhani & Elmanizar, 2019).. Meanwhile, the near-significant effect of oil prices on ROA and ROE adds to the understanding of how volatility in key commodity prices can affect the overall profitability of a company. Based on these findings, PT Pertamina needs to focus on rupiah exchange rate risk mitigation strategies due to its significant influence on Total Revenue. The use of hedging instruments, such as forward contracts or options, can help protect revenues from unfavorable exchange rate fluctuations. In addition, although oil prices are not statistically significant, their volatility remains an important factor that needs to be managed through portfolio diversification and flexible pricing strategies.

Analysis of Variance (ANOVA) is a method for comparing two or more means. ANOVA is one of the techniques in parametric statistics. ANOVA can be used as a tool to test research hypotheses that aim to assess whether there are differences in the average between groups. The final result of ANOVA is the F test value or F count. The t value is almost the same as the F value, which indicates that the statistical significance between groups will increase if the value

obtained is greater than the F value. The F test is an effective tool for determining statistical significance when comparing two groups separately (Dewi et al., 2023). If the calculated F value (F_0) exceeds the F table value, H_0 is rejected, and H_1 is accepted. Conversely, if F_0 is less than or equal to the F table value, H_1 is rejected, and H_0 is accepted. Two-factor ANOVA is also known as two-way ANOVA or two-factor analysis of variance, in contrast to one-way ANOVA. The difference lies in the number of independent variables being analyzed. The main purpose of ANOVA testing is to allow users to easily analyze several different sample groups while reducing the risk of error. In addition, ANOVA is also useful for determining the significance of differences in means when compared to other sample groups. The flexibility and adaptability of analysis of variance make it a widely used tool in an increasingly complex range of experiments.

One Way ANOVA method is used to analyze the effect of variable Cost of Goods Sold (X_{1-1}) and *Dept Ratio* (X_{3-1}) on company performance. Through this analysis, it can be seen whether changes in the two variables significantly affect the results of financial performance, so as to provide an overview of the impact of each factor on the stability and growth of the company.

Table 4. One Way ANOVA Results

Variables	F-Statistics	P-Value
X_{1-1}	1.9935	0.1920
X_{3-1}	0.5628	0.5884

From the one-way ANOVA results, the *F-Statistic* is 1.9935 and *the P-Value* is 0.1920. Since the *P-value* is greater than 0.05, there is no significant difference in cost of goods sold between time groups. This indicates that changes in cost of goods sold from 2012 to 2023 did not show significant fluctuations in the three time groups, which indicates the stability of operating costs during the period. Based on the test results involving Dept Ratio (%), the *F-statistic* value is 0.5628 and the *Z-score* is 0.5884. This research with the study of Li (2023) has the novelty of applying One-Way ANOVA to analyze the specific effect of Cost of Goods Sold (COGS) and Dept Ratio on financial performance. The results show the stability of COGS without significant fluctuations between time groups (2012-2023) and a stable Dept Ratio with a normal distribution. These findings provide more insight into long-term operational and financial stability than the general focus of risk analysis in previous studies. The low *F-statistic* value indicates that there is no significant difference in the *Dept Ratio* between the tested data groups. In addition, the *Z-score* values close to 0 also indicate that the *Dept Ratio* is within the normal distribution range. These results overall indicate that the *Dept Ratio* remains stable and does not experience significant fluctuations during the period tested.

In the risk analysis with the two-way ANOVA method, this study compares two types of risk to determine which one has a greater influence, namely market risk and liquidity risk. Market risk variables using the rupiah exchange rate (X_{2-1}), oil prices (X_{2-2}) and liquidity risk using the *current ratio* (X_{4-1}), *quick ratio* (X_{4-2}) in this method produce residual values written in the form of R, while the interaction between variables is written in the form $X_{\_2}$ for market risk and $X_{\_4}$ for liquidity risk. The results of market risk can be seen in table 5, and liquidity risk can be seen in table 6.

Table 5. Results of Two Way ANOVA (Market Risk)

Variable Y	Variable X	sum_sq	df	F	PR (>F)
Y_1	X_{2-1}	1.154305778	1.0	1.57515E-08	0.9999
Y_1	X_{2-2}	1530422165	1.0	20.88393704	0.0013

Y_1	$X_{\_2}$	329449750	1.0	4.495627413	0.0630
Y_1	R	659540366.1	9.0	-	-
Y_2	X_{2-1}	-4.00664E-08	1.0	-2.24807E-08	1.0000
Y_2	X_{2-2}	13.15037567	1.0	7.378482038	0.0237
Y_2	$X_{\_2}$	0.641748223	1.0	0.360075473	0.5633
Y_2	R	16.04034277	9.0	-	-
Y_3	X_{2-1}	-3.26586E-07	1.0	-2.05999E-08	1.0000
Y_3	X_{2-2}	476.6827756	1.0	30.06749313	0.0004
Y_3	$X_{\_2}$	54.45109764	1.0	3.434586035	0.0968
Y_3	R	142.6838268	9.0	-	-
Y_4	X_{2-1}	2.85374E-11	1.0	1.05898E-11	0.9999
Y_4	X_{2-2}	0.090952782	1.0	0.033751354	0.8583
Y_4	$X_{\_2}$	2.5926369	1.0	0.962092689	0.3523
Y_4	R	24.25310198	9.0	-	-
Y_5	X_{2-1}	-0.01237139	1.0	-1.04194E-08	1.0000
Y_5	X_{2-2}	3196353.202	1.0	2.692033983	0.1353
Y_5	$X_{\_2}$	13784622.54	1.0	11.60969078	0.0078
Y_5	R	10686038.51	9.0	-	-

The results of the market risk analysis using the *Two-Way ANOVA* method show that the *oil price* variable (X_{2-2}) has a more significant influence on most of the dependent variables analyzed compared to the *rupiah exchange rate* variable (X_{2-1}). On variables Y_1 , Y_2 , and Y_3 the effect of *oil price* is statistically significant with *p-values* of 0.0013, 0.0237, and 0.0004 respectively indicating that changes in oil prices substantially affect the performance of some variables. On the other hand, the *rupiah exchange rate* has no significant effect on these *variables*, as seen from the *p-value* which is close to 1.0000, indicating that this variable has no impact on changes in the dependent variables tested.

The interaction between variables Y_2 shows higher significance on variable Y_5 with a *p-value* of 0.0078 and an F-value of 11.6096, which indicates that the interaction between the *rupiah exchange rate* and *oil prices* has a significant influence on this variable. However, in other variables such as Y_1 , Y_2 , Y_3 , and Y_4 , the interaction between variables does not show significance. Overall, the results of this study conclude that market risk represented by *oil prices* has a greater influence on the financial performance variables tested, while the *rupiah exchange rate* shows an insignificant influence. This finding indicates the importance of considering oil price fluctuations in assessing market risk, especially in industries that are highly dependent on this commodity. The interaction between variables also shows a significant effect in some specific conditions such as in Y_5 , which can be the basis for further research on the combined impact of several risk factors on financial performance.

Table 6. Results of Two Way ANOVA (Liquidity Risk)

Variable Y	Variable X	sum_sq	df	F	PR (>F)
Y_1	X_{4-1}	5.01E+08	1.0	2.2720	0.1701
Y_1	X_{4-2}	1.87E+08	1.0	0.8468	0.3844
Y_1	$X_{\_4}$	14331551	1.0	0.0650	0.8051
Y_1	R	1.76E+09	8.0	-	-
Y_2	X_{4-1}	7.656066	1.0	3.7051	0.0904
Y_2	X_{4-2}	12.27952	1.0	5.9426	0.0407
Y_2	$X_{\_4}$	0.11033	1.0	0.0534	0.823
Y_2	R	16.53092	8.0	-	-
Y_3	X_{4-1}	33.50666	1.0	0.8043	0.3960

Y_3	X_{4-2}	150.0241	1.0	3.6013	0.0943
Y_3	$X_{\_4}$	34.76756	1.0	0.8346	0.3877
Y_3	R	333.2696	8.0	-	-
Y_4	X_{4-1}	8.732202	1.0	5.1887	0.0522
Y_4	X_{4-2}	4.671373	1.0	2.7758	0.1343
Y_4	$X_{\_4}$	3.276763	1.0	1.9471	0.2004
Y_4	R	13.46331	8.0	-	-
Y_5	X_{4-1}	612184.9	1.0	0.2242	0.6485
Y_5	X_{4-2}	1404393	1.0	0.5144	0.4937
Y_5	$X_{\_4}$	3952160	1.0	1.4475	0.2633
Y_5	R	21842725	8.0	-	-

The results of liquidity risk analysis using the *Two-Way ANOVA* method show that the variables representing liquidity risk, namely X_{4-1} and X_{4-2} have varying influence on the dependent variable. On the variable Y_1 , neither X_{4-1} nor X_{4-2} showed a significant effect, with *p-values* of 0.1701 and 0.3844 respectively. The interaction between variables X_4 also does not provide significant results (*p-value* = 0.8051), indicating that liquidity risk represented by these variables does not directly affect Y_1 . However, on variable Y_2 , variable X_{4-2} shows a significant effect with a *p-value* of 0.0407, indicating the influence of liquidity risk on Y_2 . However, the effect of X_{4-1} on Y_2 is close to significant (*p-value* = 0.0904), indicating the possibility of a larger potential effect with further testing. On Y_3 , neither X_{4-1} nor X_{4-2} showed a significant effect on the dependent variable (*p-value* = 0.3959 and 0.0943), while the interaction between variables on Y_3 was also not significant. On Y_4 , X_{4-1} shows an almost significant effect with a *p-value* of 0.0522, which indicates a potential influence of liquidity risk on Y_4 . However, the variable X_{4-2} and the interaction between variables remain insignificant on Y_4 . Meanwhile, on Y_5 none of the variables show a significant effect, with a fairly high *p-value* for variables X_{4-1} , X_{4-2} , and their interactions.

This study updates the study of (Rodrigues et al., 2024) by applying Two-Way ANOVA to analyze market risk and liquidity risk simultaneously on financial performance. The results show that market risk, particularly oil prices, has a significant influence on several dependent variables, while liquidity risk has a more limited and variable influence across variables. In addition, this study adds an inter-factor analysis, which indicates a combined effect under certain conditions, such as in Y_5 . This approach provides new insights into the importance of assessing risk interactions in commodity-based industries.

The Z-score analysis model developed by Altman in 1968 was the first model to use Multiple Discriminant Analysis (MDA). Discriminant analysis applied by Altman involves identifying various financial ratios, then developing these ratios into a Z-score model to draw conclusions about an event (Novya et al., 2016). Z-score is a method used to measure a company's financial health and assess the effectiveness of its management. The Z-score formula designed by Altman is a multivariate formula that is useful for predicting bankruptcy and assessing the financial condition of a company. The Altman Z-Score method is useful for predicting the possibility of company bankruptcy, especially in the short term. According to Mohamad Muslich (1997), companies with a Z value greater than 2.99 are considered healthy, while companies that have a value below 1.81 are classified as experiencing financial distress. Companies with Z values between 1.81 and 2.99 fall into the gray area, which indicates moderate risk. In the Altman Z-Score method, a number of key financial variables are used to measure the potential bankruptcy of the company from each year, with the variables used being working capital data (X_1), Retained Earnings (X_2), EBIT (X_3), Market Value of Equity (X_4),

Liabilities (X_5), and each divided by the asset variable. The results are graphed per year to be interpreted in Figure 3.

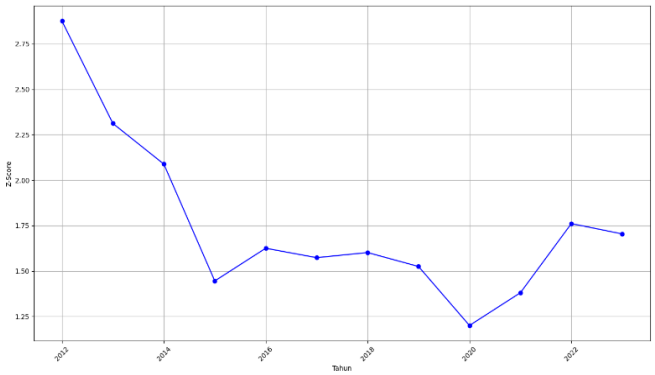


Figure 3. Altman Z-Score Results Chart

Based on the results of the Z-Score trend graph analysis from 2013 to 2023, the graph shows a consistent downward trend in Z-Score from 2013 to reach its lowest point in 2020. This decline indicates that the company experienced an increased risk of bankruptcy in that period, which could be caused by various factors such as declining profitability, increasing liabilities, or the company's inability to generate sufficient revenue. The company is in the high risk zone from 2016 to 2020, where the company's Z-Score is below the 1.8 threshold. This position puts the company at significant risk of financial distress or even bankruptcy. This condition demands serious managerial attention to reverse the negative trend and reduce the risk of bankruptcy.

After bottoming out in 2020, the Z-Score showed a moderate recovery in 2021 and 2022, with a slight further improvement in 2023. While there are signs of improvement, this improvement is still not enough to take the company out of the high-risk zone, and the company still requires strategic measures to ensure long-term financial stability. At the beginning of the analysis period in 2013 to 2015, the company was in the gray zone, where the risk of bankruptcy was present, but had not yet reached critical conditions. In this period, the company still has the opportunity to improve its financial condition if the right steps are taken. Research by Dian and Gunawan Putri (2021) uses the Altman Z-Score model to assess the risk of bankruptcy as a preventive measure, but only provides an initial overview of potential risks. The novelty of this research, analyzing long-term trends with Z-Score (2013-2023) with the crisis period, as well as identifying the causes of declining financial health and opportunities for recovery. Overall, the Z-Score analysis shows that the company has experienced a significant decline in its financial health over the past few years, with the risk of bankruptcy increasing year-on-year. While there have been signs of recovery in recent years, the company still faces significant challenges and needs a robust strategy to improve financial stability and reduce the risk of bankruptcy in the future. Management needs to review the factors that contributed to the decline in Z-Score and take the necessary corrective measures to ensure the company's operational sustainability in the long term.

Conclusion

The results show that oil price has a significant influence on total revenue, ROA, and ROE at PT Pertamina. Fluctuations in oil prices directly affect the company's revenue and profitability, while the Rupiah exchange rate shows a significant effect on total revenue, although its effect on profitability is almost insignificant. Operational risk showed a significant negative impact

on the financial viability of the project through sensitivity analysis, indicating that an increase in operational costs may cause the project to become unprofitable. Liquidity risk, although showing some influence on ROA and NPM, does not consistently affect all financial indicators, indicating that PT Pertamina's liquidity management is quite effective, although it still has a potential impact on profitability. In addition, the Altman Z-Score indicates a significant deterioration in the financial health of PT Pertamina from 2016 to 2020, although there has been a moderate recovery since 2021. The company remains in a high risk zone, which demands strategic intervention to improve its financial condition and mitigate further risks.

In facing these challenges, PT Pertamina is advised to implement several concrete steps that can strengthen the company's resilience to external risks. First, diversifying its business portfolio into renewable energy sectors such as solar and wind energy can help reduce dependence on the oil and gas sector which is vulnerable to price fluctuations. Second, strengthening the hedging strategy through the use of derivative financial instruments such as forward contracts or options is essential to protect the company from rupiah exchange rate volatility. This will minimize the negative impact of currency fluctuations on the company's earnings and enhance financial stability. In addition, operational optimization through advanced supply chain management technology and production process automation are key to controlling production costs and improving efficiency. This improvement in operational efficiency will not only help reduce Cost of Goods Sold (COGS) but also ensure the stability of raw material prices, thereby increasing the company's profit margin. The management of market risks, particularly oil prices, also needs special attention by developing flexible pricing strategies and long-term contracts that can be adjusted to global market conditions. This will help stabilize revenues and reduce the financial risks faced by the company.

Finally, improvement in key financial ratios such as working capital and EBIT as well as better debt management are necessary to improve the company's financial health. Regular monitoring of financial ratios and implementation of corrective measures will help PT Pertamina to improve its financial condition and reduce the risk of bankruptcy in the future. The adoption of digital technologies such as big data analytics and artificial intelligence is also recommended to support data-driven decision-making, enabling the company to predict market dynamics more accurately and manage risks more efficiently. The implementation of this comprehensive risk management strategy will enhance PT Pertamina's financial resilience and stability, ensuring long-term sustainability and growth in the face of global market uncertainty.

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