



PUBLISHER: <https://journal.adlermanurungpress.com/>

DOI: <https://doi.org/10.63607/jcmb.v13i3>

CAPITAL STRUCTURE, ASSET EFFICIENCY, AND RISK-ADJUSTED PERFORMANCE: EVIDENCE FROM INDONESIA'S COAL MINING SECTOR

Reni Lestari

Universitas Trisakti, Indonesia

Email: rereni12@gmail.com

Alamat: JL. Kyai Tapa No. 1 Grogol, Jakarta Barat-Indonesia

Korespondensi Penulis, rereni12@gmail.com

Abstract

This study investigates the role of capital structure and operational efficiency on risk-adjusted performance in the coal mining industry in Indonesia, a sector noted for high leverage, volatile commodity prices, and macroeconomic risk. Using balanced panel data from 19 publicly listed coal companies over the period 2015 – 2024, we estimate fixed-effects models to examine the effects of Debt-to-Equity Ratio (DER) and Total Asset Turnover (TATO) on Risk-Adjusted Return on Capital (RAROC), using firm-level risk, measured by the rolling standard deviation of Return on Assets (ROA), as a mediator and firm size as a moderator. The results of this study demonstrate that DER negatively impacts RAROC, and TATO positively impacts RAROC. Firm-level risk partially mediates the effect of operational efficiency (TATO) on RAROC, accounting for approximately 21% of the total effect, but does not mediate the relationship between capital structure (DER) and RAROC. Finally, firm size moderated both relationships: first, firm size buffers the negative impact of DER; while, against expectations, firm size weakens the positive impact of TATO on RAROC. Volatility in the exchange rate increases firm risk; and there is no direct effect of macroeconomic variables on performance. These outcomes contribute to understanding risk-adjusted performance and capital structure in emerging markets, and have practical implications for managing financing strategies in an uncertain world.

Keywords: Capital structure, TATO, RAROC, Firm-level Risk, Coal mining Sector

INTRODUCTION

For capital-intensive, cyclical industries such as coal mining, firm performance is determined by factors that include return on capital, and standard return measures alone are insufficient. Consequently, a holistic evaluation must consider both returns and the risk of generating those returns. Risk-Adjusted Return on Capital (RAROC), a return measure which integrates performance with risk exposure, has become a leading tool which enhances the decisions faced by managers when

allocating capital (Saunders & Allen, 2020; Caselli & Gatti, 2023. Although RAROC was primarily designed for the banking sector, its use in non-financial industries has grown given the recent increases in financial uncertainty and volatility in operating environments (Resti & Sironi, 2007; Raj, 2021.)

The coal mining industry in Indonesia is significant for the national economy and has unique challenges related to cyclical demand, volatile commodity prices and macroeconomic instability. Previous literature has examined capital structure (DER) and operational efficiency (TATO) separately, while their combined effect on risk-adjusted returns (RAROC) has not been investigated, especially in an emerging market that's depended heavily on resource commodities, where financial sustainability and resilience is paramount. This study sought to help address this gap by explicitly incorporating firm-level risk (ROA volatility) as a mediating variable, and firm size as a moderating variable, revealing a new way for coal mining firms to balance leverage, operational efficiency and risk and manage uncertainty.

One important dimension of this relationship could be financial risk, which could either enhance or mitigate the influence that DER and TATO have on performance. In this paper, risk is treated as a moderating variable and is represented by Return on Assets (ROA) volatility, which is a well-accepted proxy for internal risk that is aligned with earnings stability (Bali, Cakici, & Whitelaw, 2011; Hong, 2023). ROA volatility defines a firm's specific exposure to operational and financial shocks and is appropriate for examining how instability at the firm-level may have an impact on the realization of capital and asset management strategies.

The moderating impact of risk is also compounded by firm size which can affect risk appetite and access to financing. For example, larger firms will typically have a more consistent cash flow, typically have better access to capital markets, and likely have support from institutional investors that help insulate them from the impact of economic shocks (Beck, Demirgüç-Kunt, & Maksimovic, 2005; Zahoor et al., 2022). Finally, to account for the influence of macroeconomic indicators (such as interest rate and exchange rate levels) on valuation, low cost of capital and investor confidence (and especially in developing markets), they (along with risk appetite and firm size) are included as control variables (Barrell et al., 2012; Wulandari et al., 2023).

Although the interdependencies mentioned here are pertinent and important, empirical research in the coal industry in Indonesia is somewhat limited. Most previous studies did not sufficiently address the joint effect of DER and TATO on risk-adjusted performance or sufficiently address the moderating effect of firm-level risk; suggesting a gap. This study seeks to address this gap within the literature by exploring how DER and TATO affect RAROC by including moderators (i.e., ROA volatility and firm size), and controls (i.e., interest and exchange rates) for macroeconomic variables. Applying a balanced panel of coal mining firms from 2015 to 2024 combined with robust econometrics, the contributions of this study will advance the development of literature generally in relation to risk-performance and concluding with strategies for improved risk-informed decision making in industries characterized by high volatility.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Literature Review

This study is based on several theories, that provide explanations of how firm financial decisions including capital structure and efficiency of assets, influence risk-adjusted performance, for a sector like coal mining, which is characterized by capital intensity and volatility. This study uses Risk-Adjusted Return on Capital (RAROC) as the dependent variable, representing the trade-off between return and risk. The theoretical model developed has five constructs: capital structure (debt-to-equity ratio (DER)), efficiency of assets (total asset turnover (TATO)), firm risk (volatility of return-on-assets (ROA)), firm size, and macroeconomic conditions (interest rates and exchange rates). In designing these variables, the Trade-Off Theory, Pecking Order Theory, Resource-Based View (RBV), and Risk-Return Tradeoff Theory underpin the theoretical framework.

Risk-Adjusted Performance (RAROC)

RAROC assesses a company's ability to generate returns relative to the risk acquired (Micu & Micu, 2006). It was developed for the banking industry and is now used in most capital-intensive, high-risk industries, including mining, to manage the trade-off between risk and return (Dittmann, 2011). RAROC considers both expected losses and unexpected losses, and is represented as follows:

$$RAROC = \frac{NOPAT - Expected Loss}{Economic Capital}$$

Where NOPAT is net operating profit after tax, Expected Loss reflects the average projected losses, and Economic Capital denotes capital set aside to absorb unexpected losses (Bessis, 2015).

Capital Structure (DER)

The Debt-to-Equity Ratio (DER) has implications for a firm's reliance on external debt as financing. The Trade-Off Theory (Kraus & Litzenberger, 1973) indicates that debt can provide a tax benefit, but with increased leverage comes greater probability of financial distress and bankruptcy – an important consideration for a company in a cyclical industry like coal mining. Further, the Pecking Order Theory (Myers, 1984) states that firms prefer to finance internally and only issue debt if internal funding is insufficient. Thus, a high DER is expected to increase firm-level risk and reduce RAROC.

$$DER = \frac{Total Liabilities}{Total Equity}$$

Empirical studies such as Booth et al. (2001) support this negative relationship, especially in emerging markets with weaker creditor protection and more volatile macro environments.

Operational Efficiency (TATO)

Operational efficiency is indicated with the Total Asset Turnover (TATO) which measures the efficiency of revenues produced from assets. Based on the Resource-Based View (Barney, 1991), firms that have superior internal resources and capabilities are more likely to maintain higher, more stable performance. Specifically, as one internal resource, asset efficiency allows firms to equalize revenue growth and expenditures, indicating efficiency.

$$TATO = \frac{Revenue}{Total Assets}$$

Higher TATO is thus expected to enhance RAROC directly and reduce risk indirectly by stabilizing earnings. Ross et al. (2016) emphasize TATO as a critical performance indicator, especially in asset-intensive industries.

Firm-Level Risk (Volatility of ROA)

Risk, as defined by the rolling standard deviation of Return on Assets (ROA), represents the magnitude of a firm's profit variation (i.e., it refers to how much a firm's profitability is fluctuating over time). Therefore, as the Risk-Return Tradeoff Theory suggests (Markowitz 1952, Sharpe 1964), if a firm is subjected to greater risk, higher economic capital must be used to protect against potential losses and thus RAROC will reduce.

$$Risk = \sigma_{ROA}^{(t-2,t)} \quad (\text{Rolling 3-Years Std. Deviation of ROA})$$

Where:

$$ROA = \frac{Net Income}{Total Assets}$$

Bali, Cakici, and Whitelaw (2011) confirm that earnings volatility serves as a reliable indicator of firm-specific risk, particularly in emerging markets.

Firm Size

Firm Size, as measured by the total assets natural log, moderates the relationships between DER and TATO and RAROC. Based on the Pecking Order Theory and the Size-Buffer Hypothesis (Frank and Goyal, 2009), larger firms benefit from more stable cash flows, better credit ratings, and

better access to capital markets. These benefits can reduce the adverse effects of leverage and may have augmented the positive benefit from efficiency.

$$Size = \ln (Total Assets)$$

Rajan and Zingales (1995) and Beck, Demirgüç-Kunt, and Maksimovic (2005) demonstrate that size mitigates financing frictions and strengthens resilience to economic shocks.

Interest Rate and Exchange Rate (Forex)

The model also includes macroeconomic variables as controls to account for external shocks

- Interest Rate: Bank Indonesia 7-Day Reverse Repo Rate
- Exchange Rate (Forex): IDR/USD closing average

According to Cost of Capital Theory (Mishkin, 2016), when interest rates increase, the cost of borrowing rises, while the volatility of the exchange rate impacts the revenue and cost stability, both factors that are particularly important in trade or export-based industries, such as coal. Bartram, Brown and Conrad (2010) note these macroeconomic factors are significant determinants of firm-level risk and valuations.

Bringing these elements together, then conceptual structure is visualized in the following diagram:

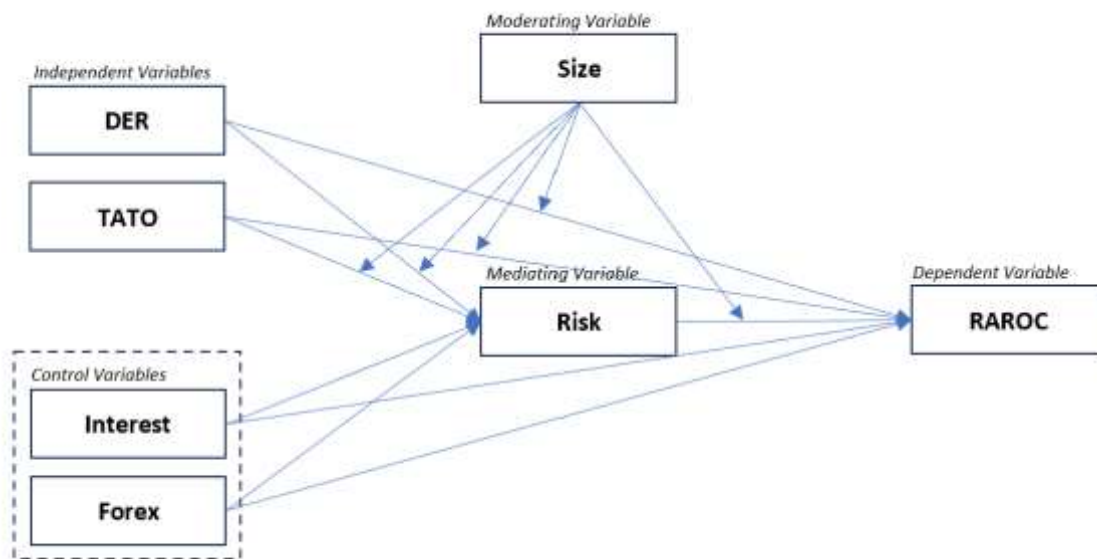


Figure 1. Theoretical Framework of the Study

The diagram shows DER and TATO as independent variables influencing RAROC both directly and indirectly via Risk. Firm Size moderates the effect of DER and TATO, while Interest and Forex serve as control variables influencing Risk and performance.

Hypothesis Development

Using the theoretical frameworks and the previous body of literature as a foundation, this section contributes hypotheses regarding how capital structure and operating efficiency impact risk-adjusted performance (RAROC) in the case of the Indonesian coal mining industry, as well as including the roles of firm-level risk (as a mediator), firm size (as a moderator) and macroeconomic factors (as control variables).

Capital Structure, Operational Efficiency, and RAROC

According to the Trade-Off Theory of capital structure, higher levels of debt, or excessive leverage heighten bankruptcy risk and raise the cost of capital, thus negatively affecting firm performance. Given that the Indonesian coal firms operate in cyclical and volatile price conditions, reliance on debt financing ought to negatively impact RAROC. This leads us to propose the first hypothesis:

- H1: DER (Debt-to-Equity Ratio) has a negative effect on RAROC.

Conversely, the Resource-Based View contends that firms achieve sustained and superior performance based on to their internal capabilities, including efficient use of assets. High Total Asset Turnover (TATO) is indicative of efficient resource utilization; therefore, the expectation is it would lead to RAROC. It is accordingly proposed that:

- H2: TATO (Total Asset Turnover) has a positive effect on RAROC.

Risk as a Mediating Variable

The Leverage–Risk Link states that higher leverage causes greater volatility in earnings because it improves on the firm’s debt obligations, while higher operational efficiencies decrease volatility in earnings because the firm is using its resources better. These connections support the role of firm-level risk (as proxied by the rolling standard deviation of ROA, see Backen et al 2020) as a mediator. Based on Baron and Kenny’s (1986) mediation framework, as well as the Risk–Return Tradeoff Theory, I suggest the following hypotheses:

- H3: DER has a positive effect on Risk (volatility of ROA).
- H4: TATO has a negative effect on Risk.

In turn, higher risk increases the economic capital required to absorb potential losses, thus reducing RAROC:

- H5a: Risk mediates the relationship between DER and RAROC.
- H5b: Risk mediates the relationship between TATO and RAROC.

Firm Size as a Moderating Variable

According to Pecking Order Theory and the Size Buffer Hypothesis, larger firms have more access to capital markets and may be more shock-resistant, which may offset the negative effects of leverage on performance. At the same time, economies of scale and greater control over operations in larger firms can strengthen the positive effects of efficiency. As a result, firm size is hypothesized to moderate the relationships between DER, TATO, and RAROC:

- H6: Firm size moderates the relationship between DER and RAROC, such that the negative effect of DER will be weaker for firms that are larger.
- H7: Firm size moderates the relationship between TATO and RAROC, such that the positive effect of TATO will be stronger for firms that are larger.

Macroeconomic Control

Based on the Cost of Capital Theory (Mishkin, 2016), increasing interest rates will raise borrowing costs, while exchange rate changes will create a currency risk for firms, thereby negatively impacting firm performance. Moreover, these external forces may create earnings volatility, especially in exports dependent industries like coal. The following hypotheses are proposed:

- H8: Interest rate has a negative effect on RAROC.
- H9: Exchange rate has a negative effect on RAROC.
- H10: Interest rate has a positive effect on Risk.
- H11: Exchange rate has a positive effect on Risk.

RESEARCH METHODOLOGY

Data and Sample

This study uses panel data from coal mining firms listed on the Indonesia Stock Exchange (IDX) years 2015-2024. The final sample was selected based on three criteria: (1) where it was listed for the whole study period (2015 - 2024), (2) where the company has complete audited financial statements, (3) where the principal business is coal mining. Financial data are collected from audited financial statements and macroeconomic and indicators are sources of evidence from Bank Indonesia and BPS (Badan Pusat Statistik). The processing and analysis of all data were conducted using Stata 17. The final samples include balance panel data with 10 observations over 19 firm, 190 observations over firm-year.

Model Specification

This study employs a quantitative panel data and applies fixed-effects regression to examine the relationship between both capital structure and operating efficiency on risk adjusted performance (RAROC), holding macroeconomic factors constant and accounting for mediation and moderation. RFBA considers different estimation strategies including Baron and Kenny's (1986) mediation methods, interaction models in the case of moderation, and Sobel tests for significance.

All models are estimated using fixed-effects (FE) indicators for unobserved heterogeneity, and standard errors clustered at the firm-level to account for heteroscedasticity and possible autocorrelation (Wooldridge, 2010; Hsiao, 2014).

Moderation Model: Direct and Moderating Effects

The first model assesses the direct effects of DER and TATO on RAROC (H1–H2), as well as the moderating effects of firm size on these relationships (H6–H7). It also controls for macroeconomic variables: interest rates and exchange rates (H8–H9).

$$RAROC_{it} = \alpha_i + \beta_1 \cdot DER_{it} + \beta_2 \cdot TATO_{it} + \beta_3 \cdot Size_{it} + \beta_4 \cdot (DER \times Size)_{it} + \beta_5 \cdot (TATO \times Size)_{it} + \beta_6 \cdot Interest_t + \beta_7 \cdot Forex_t + \varepsilon_{it}$$

This specification tests:

- Direct effects: H1 (DER → RAROC), H2 (TATO → RAROC)
- Moderation: H6 (Size × DER), H7 (Size × TATO)
- Controls: H8 (Interest), H9 (Forex)

Mediation Model: Risk as a Mediating Variable

The second model follows the Baron and Kenny (1986) approach to test whether firm-level risk mediates the effects of DER and TATO on RAROC (H3–H5). This approach consists of two stages:

Stage 1: Risk Equation

$$Risk_{it} = \alpha_i + \gamma_1 \cdot DER_{it1} + \gamma_2 \cdot TATO_{it} + \gamma_3 \cdot Interest_t + \gamma_4 \cdot Forex_t + u_{it}$$

This model estimates the effect of DER and TATO on the mediator (Risk), while controlling for macroeconomic variables.

This stage tests:

- H3: DER → Risk
- H4: TATO → Risk
- H10–H11: Macro variables → Risk

The second stage includes the mediator into the RAROC regression to test for mediation:

$$RAROC_{it} = \alpha_i + \delta_1 \cdot DER_{it1} + \delta_2 \cdot TATO_{it} + \delta_3 \cdot Risk_{it} + \delta_4 \cdot Interest_t + \delta_5 \cdot Forex_t + \varepsilon_{it}$$

Mediation is supported if:

- H5a: Risk mediates DER → RAROC
- H5b: Risk mediates TATO → RAROC
- Reassessment of macro controls (H8–H9)

Sobel Test for Mediation

To assess the statistical significance of the mediation (indirect effect), the Sobel test is employed (MacKinnon, Lockwood, & Williams, 2002). The Sobel z-value is calculated as:

The Sobel z-value is calculated as:

$$z = \frac{a \cdot b}{\sqrt{b^2 \cdot s_a^2 + a^2 \cdot s_b^2}}$$

Where:

- *a* is coefficient from IV → Mediator (e.g., TATO → Risk)
- *b* is coefficient from Mediator → DV (Risk → RAROC)
- *s_a* and *s_b* are the standard errors of *a* and *b*, respectively

A significant z-statistic (e.g., |z| > 1.96 at α = 0.05) supports the presence of mediation.

RESULTS AND DISCUSSION

Descriptive Statistics

Table 1 contains the descriptive statistics for the main variables for the study. RAROC averaged 0.17 with a high standard deviation of 1.21, which indicates considerable variability in firm-level risk-adjusted performance among coal mining firms in Indonesia. The average debt-to-equity ratio (DER) was 1.72 and average total asset turnover (TATO) is 0.06, suggesting that firms are not able to utilize their assets very efficiently in the coal mining sector. Firm risk, proxied by Volatility of ROA, averaged 0.099 and had considerable dispersion (SD = 0.209). Macroeconomic controls—interest rate and exchange rate—had relatively low volatility, which is consistent with Indonesia’s monetary policy during the study period (2015–2024).

Variable	Obs	Mean	Std. dev.	Min	Max
RAROC	190	0.170	1.208	-12.544	2.252
DER	190	1.720	3.703	-4.305	34.056
TATO	190	0.062	0.313	-3.540	0.616
Risk	190	0.099	0.209	0.002	2.078
Size	190	29.651	2.054	22.077	32.754
Interest	190	0.052	0.012	0.035	0.075
Forex	190	9.569	0.055	9.498	9.673

Table 2: Descriptive Statistics

Correlation and Multicollinearity Analysis

A pairwise correlation analysis was undertaken to explore the direction and strength of association among variables. A summary of the analysis is contained in Table 2. RAROC has a positive correlation with TATO ($r = 0.8581$, $p < 0.01$), and negative correlation with DER ($r = -0.2329$, $p < 0.01$) and Risk ($r = -0.7209$, $p < 0.01$). The positive correlations mean increases in operational efficiency (TATO) is associated with an increase in RAROC. However, on the other hand negative correlations with DER (leverage) and Risk shows higher leverage and risk would have combined to reduce RAROC.

Variables	RAROC	DER	TATO	Risk	Size	Interest	Forex
RAROC	1						
DER	-0.233	1					
TATO	0.858	-0.093	1				
Risk	-0.721	0.052	-0.607	1			
Size	0.426	0.102	0.383	-0.372	1		
Interest	-0.075	-0.025	-0.091	0.04	0.009	1	
Forex	-0.023	-0.025	0.072	0.171	0.105	0.119	1

Table 3: Correlation Matrix

To evaluate multicollinearity the Variance Inflation Factor (VIF) test was conducted and it is noted that all values are far below the standard cutoff of 10, and the mean VIF is 1.102. Thus, concerns regarding multicollinearity are classified as non-issue.

Variable	VIF	1/VIF
TATO	1.21	0.825
Size	1.21	0.826
DER	1.03	0.967
Forex	1.03	0.972
Interest	1.03	0.973
Mean	1.102	0.913

Table 4: Multicollinearity Test

Moderation Model Estimation and Discussion

The results of the estimated moderation model, specifying both direct effects and interaction terms between the DER and Size, and TATO and Size, to evaluate the presence of firm size as a moderator. The model included interest rate and exchange rate as control variables.

Variable	Coefficient	Std. Error	t-stat	p-value
DER	-1.364	0.196	-6.960	0.000
TATO	6.491	0.891	7.290	0.000
Size (main)	0.099	0.121	0.830	0.420
DER × Size	0.043	0.006	7.190	0.000
TATO × Size	-0.141	0.041	-3.430	0.003
Interest	1.488	2.002	0.740	0.467
Forex	-1.100	0.900	-1.220	0.237
Within R ²	0.872	Explains 87.2% of within-firm variation		
Between R ²	0.883	Explains 88.3% of between-firm variation		
Overall R ²	0.857	Explains 85.7% of total variation in RAROC		
F-test (Prob > F)	36,359.34 (0.000)	Model is statistically significant		
Hausman Test (FE vs. RE)	64.79 (0.000)	Fixed-effects preferred over random-effects		
Heteroskedasticity Test:	$\chi^2=12,797.60$ (0.000)	Groupwise heteroskedasticity detected; robust SE used		
Rho (s ² _u / s ² _{total})	0.329	32.9% of variance due to firm-level effects		

Table 5: Moderation Model Estimation Result

The findings indicate that the capital structure (DER) has a negative and statistically significant relationship with RAROC ($\beta = -1.364$, $p < 0.001$), thus supporting H1 and consistent with the Trade-Off Theory (Kraus & Litzenberger, 1973), which assumes the costs of financial distress increase with the amount of leverage, leading to a decrease in the performance of the firm. Thus, this is similar to the findings of Titman and Wessels (1988) and Booth et al. (2001), who found the costs of a high level of debt are higher in volatile industries because the risk premium and bankruptcy risk are higher.

In contrast, TATO has a positive and statistically significant relationship with RAROC ($\beta = 6.491$, $p < 0.001$) thus supporting H2. In general, there is some theoretical support in the Resource-Based View (Barney, 1991) as firms with better internal resources – in this case high asset efficiency – are able to achieve sustainable competitive advantage compared to others. In addition, empirical studies on emerging markets (e.g. Zhang & Wang, 2020; Suhardianto et al., 2021) have found that operational efficiency leads to higher profitability and stability in returns—especially in resource-intensive industries.

With regard to moderation effects, the interaction term DER × Size is positive and statistically significant ($\beta = 0.043$, $p < 0.001$), in which case H6 is confirmed. This result aligns with both the Pecking Order Theory (Myers, 1984), and the Size–Buffer Hypothesis (Frank & Goyal, 2009), where larger firms have a higher level of financial flexibility, are able to access capital markets more easily, and have a greater share of institutional support, which allow larger firms to better withstand the negative impacts of high leverage. Thus, the moderating effect of size in relation to capital structure-performance relationships has support from the studies by Beck et al. (2005), and Dang, Kim, & Shin (2012).

Unexpectedly, the interaction term TATO × Size is negative and significant ($\beta = -0.141$, $p = 0.003$), which we did not predict in Hypothesis H7 that larger firms would receive more gains from having an efficiency. The negative interaction term implies that either complexity associated with scaling or diminishing marginal returns to operational efficiency has occurred as firm size increases. Prior research has identified that larger firms can incur coordination difficulties, bureaucratic inertia,

or disconnects between operations and strategy beyond a specific scale (Bloom, Sadun, & Van Reenen, 2016) which all may offset increases in asset turnover. Given these contrary findings, it suggests that the performance improvements linked to efficiency have a ceiling, or even a negative growth function when asset scalability is at the extreme, particularly in heavy industry, such as coal mining where firm size and physical asset scaling is relatively rigid.

In terms of some macroeconomic control variables, interest rate ($p = 0.467$) and exchange rate ($p = 0.237$) have no significant direct effect on RAROC, therefore Hypotheses H8 and H9 remain unsupported. This resonates partially with prior studies which have claimed that at times macroeconomic variables have indirect or lagged effects (Mishkin, 2016; Aggarwal & Harper, 2010). Furthermore, it is likely the lack of direct effects is a result of lower macrovolatility impacts on firm performance via risk management techniques or hedging strategies exercised by larger listed coal firms.

In sum, this model is very strongly predictive with a within R-square of 0.872 indicating the regressors account for just over 87% of the variation in RAROC over time within firms. Fixed-effects modeling was confirmed appropriate by the Hausman test, and then corrected for groupwise heteroskedasticity with robust standard errors clustered at the firm level based on the large number of firms flagged for HE. There were no issues with multicollinearity, as shown with VIF diagnostics (O'Brien, 2007).

Mediation Effect

This research investigates if firm-level Risk (volatility of ROA) mediates the relationships between DER (capital structure), TATO (operational efficiency), and RAROC (risk-adjusted return) according to Baron and Kenny's (1986) mediation analysis framework and supported by Sobel testing.

Step 1: Effect of DER and TATO on Risk (Mediator)

The first-stage regression evaluates how DER and TATO influence Risk:

Variable	Coefficient	Std. Error	t-stat	p-value
DER	0.007	0.010	0.680	0.504
TATO	-0.441	0.094	-4.680	0.000
Interest	-0.789	0.469	-1.680	0.110
Forex	0.867	0.400	2.170	0.044
Within R ²	0.450	Explains 45.0% of within-firm variation		
Between R ²	0.285	Explains 28.5% of between-firm variation		
Overall R ²	0.405	Explains 40.5% of total variation in Risk		
F-test (Prob > F)	36.28 (0.000)	Model is statistically significant		
Heteroskedasticity Test	$\chi^2 = 12,797.60$ (0.000)	Robust standard errors used.		
Rho (s ² u / s ² total)	0.256	25.6% variance due to firm effects		

Table 6: Step 1 Mediation Effect Result

The first-stage regression was to see if capital structure (DER) and operational efficiency (TATO) influences firm-level Risk (volatility of ROA), while accounting for macroeconomic influences. The results present three distinct findings. First, TATO was found to have a strongly significant negative relationship with Risk (coefficient = -0.441, $p < 0.001$): thus providing support for H4. This finding aligns with the Resource-Based View, which suggested that firms with a higher asset turnover would provide a more stable earning stream, as firms typically know with greater certainty their abilities to generate predictable revenues if they are using resources efficiently. Second, there was a non-significant effect of DER on Risk ($p = 0.504$), which does not support H3. However, this finding aligns with anecdotal evidence that showed that Indonesian coal firms tended to use debt conservatively (e.g., using short-term debt for working capital and long-term contracts to hedge against financial risk). As a result, variance in earnings associated with leverage influenced companies in this sector, but they do not realize the amplified variance in earnings, which contradicts

Trade-Off Theory assumptions of leverage in developing countries. Third, focusing on the macroeconomic controls, we find that Forex has a significant effect of increasing Risk (coefficient = 0.867, $p=0.044$), thus, supporting H11 (Exchange rate has a positive effect on Risk).

Step 2: Mediation Model (Risk Included in RAROC Regression)

The second stage tests mediation by adding Risk to the RAROC model:

Variable	Coefficient	Std. Error	t-stat	p-value
DER	-0.088	0.026	-3.350	0.004
TATO	2.610	0.164	15.940	0.000
Risk	-1.597	0.358	-4.460	0.000
Interest	-0.574	1.631	-0.350	0.729
Forex	-0.677	0.835	-0.810	0.428
Within R ²	0.836	Explains 83.6% of within-firm variation		
Between R ²	0.744	Explains 74.4% of between-firm variation		
Overall R ²	0.812	Explains 85.7% of total variation in RAROC		
F-test (Prob > F)	1,273.48 (0.000)	Model is statistically significant		
Rho (s ² _u / s ² _{total})	0.314	31.4% variance due to firm effects		
Hausman Test:	64.79 (0.000)	Fixed-effects preferred		

Table 7: Step 2 Mediation Effect Result

The second-stage regression analyses provide valuable evidence regarding the mediating role of Risk between financial/operational variables and RAROC. The analyses show that firm-level Risk (the volatility of ROA) has a highly significant negative effect on RAROC (coefficient = -1.597, $p < 0.001$), supporting the premise that higher risk reduces RAROC, which is a necessary condition of mediation for H5a-H5b to hold. The model explained a remarkable 83.6% of the within-firm variation (Within R² = 0.836) and 81.2% of the total variation (Overall R² = 0.812) with 31.4% of the variance accounted for by firm-level effects (Rho = 0.314), which offers compelling evidence for explanatory power.

For the partial mediation effects, we see that the DER (directing efficient resource) maintains a significant negative direct effect on RAROC (coefficient = -0.088, $p = 0.004$), though a slight reduction in the direct effect when compared to the baseline model (-0.099). It seems that Risk only faintly mediates the leverage-performance relationship in the case of DER. Additionally, TATO continues to have a significant positive impact on RAROC (coefficient = 2.610, $p < 0.001$), along with a sizeable reduction in the coefficient from the baseline model (3.314), suggesting that Risk mediates approx 21% of TATO's effect on RAROC. This form of partial mediation suggests that if operational efficiency is a major driver of performance, the operational drive is occurring within two different channels, directly (i.e., increased productivity) and indirectly (i.e., reduced risk). But we suspect that the effects are still driven primarily through direct performance increases.

The macroeconomic controls show no significant effects in this specification (Interest: $p = 0.729$; Forex: $p = 0.428$), suggesting that once firm-level Risk is considered, their effects on RAROC are trivial. The Hausman test ($\chi^2 = 64.79$, $p = 0.000$) supports the appropriateness of the fixed-effects specification and considered possible endogeneity. This collective evidence highlights Risk as an important - though partial - transmission channel through which both capital structure and operational efficiency ultimately have an impact on corporate performance.

Mediation Summary:

Pathway	Baseline Coef (p)	With Mediator Coef (p)	Change	Mediation Type
DER --> RAROC	-0.099 (0.000)	-0.088 (0.004)	↓ 11%	Partial
TATO --> RAROC	3.314 (0.000)	2.610 (0.000)	↓ 21%	Partial

Table 8: Mediation Summary Result

The Baseline Coefficient values contained in the mediation summary are the direct effects of DER and TATO on RAROC from the model without the risk mediator and firm size interactions, but with

the control variables. The mediation analysis suggests some interesting insights about how the effects of capital structure and operational efficiency transmit on risk-adjusted performance through firm-level Risk. For the DER-RAROC effect in particular, we observe partial mediation where the coefficient decreased by 11% (from -0.099 to -0.088) when Risk was modeled while still demonstrating strong significance ($p = 0.004$).

Mediation Path	a (X → M)	sa	b (M → Y)	sb	Sobel z-value	p-value (approx)
DER → Risk → RAROC	0.0065	0.0096	-1.597	0.3581	-0.669	0.503
TATO → Risk → RAROC	-0.4408	0.0942	-1.597	0.3581	3.228	0.0012

Table 9: Sobel Test Result

The Sobel test verifies these observations. The Sobel z-value for the mediation path from DER through Risk to RAROC is -0.669, and is non-significant, suggesting the mediating effect of Risk over the DER–RAROC link is very weak. Therefore, Hypothesis H5a is not supported. With respect to Hypothesis H5b, the Sobel test for the mediation path from TATO through Risk to RAROC yields a z-value of 3.228 ($p < 0.01$) which indicates the existence of a statistically significant mediation effect. This z-value provides a strong case for Risk's mediation of the relation between TATO and RAROC. Hypothesis H5b is supported.

In summary, the mediation analysis highlights that operational efficiency offers a benefit to risk-adjusted performance both directly, as well as indirectly, through a reduction in earnings volatility. By contrast, it appears that the effect of leverage on risk-adjusted returns happens primarily through direct routes.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study illustrates the complexity of capital structure, operational efficiency and risk-adjusted performance (RAROC) for the coal mining industry in Indonesia. Capital structure (leverage) (DER) significantly reduces RAROC, verifying Trade-Off Theory, as increased levels of debt create increased financial distress costs, which detract from risk-adjusted returns. This negative overall effect from leverage declines in larger firms, where their size enables the management of risk from debt more effectively. Operational efficiency (TATO) enhances RAROC significantly and supports the Resource-Based View wherein the productive use of assets enhances profitability and yields the greatest stability. The findings do suggest this benefit diminishes, and potentially disappears in larger firms signifying increasing operational complexity or diseconomies of scale may erase the value of operational efficiency for larger firms.

The study goes on to show, firm-level risk (the volatility of ROA) partially moderates the TATO-RAROC relationship, meaning operational efficiency provides a dual benefit of directly enhancing performance, while also indirectly stabilizing earnings. Firm-level risk does not moderate the DER-RAROC relationship reinforcing that leverage exerts a more direct effect. While macroeconomic variables did not exert direct impacts upon RAROC, there does appear to be an exasperating effect of exchange rate volatility upon firm-level risk, reaffirming the sensitivity of the coal mining industry to external shocks. Overall, the study presents the wisdom from balancing debt policies with operational agility and the management of risk in volatile industries such as coal mining.

Suggestions

This research offers useful insights for corporate managers, policymakers, and communities concerned with coal mining. For corporate managers, the results highlight the importance of striking a balance between leverage and operational efficiency to optimize risk-adjusted returns. While firms will always carry some debt (i.e., DER), debt levels that are too high hinder performance, and this study suggests those firms need to be careful to carry debt levels that are below a certain threshold, essentially amounting to a level of financing that is conservative for the firm's industry. Firms should also consider asset utilization (TATO) through operational efficiencies and improving technology.

(Inevitably, large firms will have diseconomies of scale that could strip efficiencies away). Regarding financial planning, managers would be wise to incorporate a level of risk metrics around that planning, i.e., volatility of return on asset (ROA), that could help reduce uncertainty and stabilize returns. For policymakers and regulators, the findings point to the need for guidelines for encouraging sustainable capital structures in cyclical industries (like coal mining), for capital incentives for project level efficiency-enhancing investment, and, more generally, for establishing policies to minimize risk at the macro level, particularly for risks associated with currency and exchange rates with respect to capital access and firm level uncertainty.

Future research should build on these results by investigating cross-industry or cross-country comparisons, especially in other resource-intensive industries, to evaluate the applicability of the results. Other risk measures, such as market-based risk measures (eg. beta, credit spreads), or financial distress measures (eg. Altman's Z-score) would also provide a more holistic picture of the risk of firms. Employing Dynamic Panel Model such as GMM estimators, would help in combatting endogeneity issues. Incorporating ESG factors would further allow researchers to examine how sustainability pressure interacts with a firm's capital structure and performance. Provide qualitative perspectives from practitioners in the field, could provide useful insights on managerial decision-making in volatile market conditions. These extensions would further narrow the gap between the academic research and reality of financial decisions in an organization.

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