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Navigating the Commodity Rollercoaster: Efficiency, Firm Size and Profitability in Mining Manufacturing under Price Volatility (2020-2024)

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Abstract: This study analyzes the profitability of mining manufacturing companies in Indonesia, focusing on the period of high commodity price volatility from 2020 to 2024. The objective is to examine the influence of operational efficiency and firm size on profitability (EBITDA Margin), as well as the moderating role of commodity price volatility in this relationship. The method used is quantitative, with panel data from 53 companies listed on the Indonesia Stock Exchange (IDX), analyzed using panel data regression with the Fixed Effects model. The results prove that operational efficiency has a negative effect on profitability, and firm size also has a negative effect on profitability. Commodity price volatility strengthens the positive effect of operational efficiency but, conversely, weakens the negative effect of firm size on profitability. In times of price uncertainty, operational efficiency becomes a more crucial factor in determining profitability resilience than the size of the firm.

Keywords: operational efficiency, firm size, profitability, commodity price volatility, mining manufacturing.

INTRODUCTION

The analysis of mining commodity price fluctuations for the 2020–2024 period (based on *The Pink Sheet Commodity Price Annual Data*–World Bank) shows a uniform pattern: a sharp upward trend (2020-2022) driven by global economic recovery and supply disruptions, followed by a significant correction (2022-2023) due to market normalization and economic slowdown.This phenomenon is closely related to the post-COVID-19 global economic recovery which is driving a surge in demand, as well as supply disruptions due to the Russia-Ukraine war. However, in the 2022–2023 period, the prices of most of these commodities experienced a sharp decline due to market normalization, a global economic slowdown, and an increase in supply in several sectors. Two important exceptions are: (1) Gold, which stabilized then soared (2023-2024) as a safe-haven asset; and (2) Copper, which rebounds in 2024 due to expected demand from the energy transition and electrification.

For companies in the mining manufacturing sector, the volatility of commodity prices causes income and margin uncertainty, so risk management strategies, such as *hedging*, are crucial to maintain financial performance (Damodaran, 2012). On the other hand, internal factors remain the main determinants of profitability, which in the context of this industry is generally measured using EBITDA margin because this indicator provides an overview of operational performance that is free from the influence of capital structure and non-cash costs (Damodaran, 2012). Two internal factors that are often the focus of research are operational efficiency and company size. Operational efficiency, which is typically measured by *the Operating Cost Ratio (OCR),* reflects a company's ability to control operating costs relative to revenue (Hitt et al., 2017). Meanwhile, company size, generally measured by the natural logarithm of total assets (*Ln* total assets), reflects capital capacity, resilience to cost fluctuations, and potential *economies of scale* (Hillier et al., 2021).

A number of studies in Indonesia show that good operational efficiency and larger company size are positively related to profitability (Rachmawati & Triyono, 2021). However, most of the research was conducted in relatively stable market periods, so it has not been widely tested in the context of extreme uncertainty due to commodity price volatility. In fact, the modern financial literature indicates two possible moderating effects of price volatility on the relationship. First, volatility can amplify the influence of efficiency and size on profitability if companies are able to leverage operating size and cost controls to survive amid fluctuations (Brealey et al., 2019). Second, volatility can weaken the relationship if a surge in market risk increases hedging costs and pressures on cash flow, eroding profit margins.

In the *framework of the Resource-Based View* (RBV), operational efficiency and company scale are strategic capabilities that meet the criteria of VRIN (*valuable*, *rare*, *inimitable*, non-substitutable), and can certainly produce sustainable competitive advantage if supported by *dynamic capabilities* (Barney, 1991; D. J. Teece, 2007). However, as emphasized by *Contingency Theory*, the effectiveness of these capabilities is highly dependent on external environmental conditions, in this case commodity price volatility which requires an adaptive and responsive internal strategy to maintain optimal performance (Pindyck, 2004). Furthermore, the literature on commodity price volatility outlines that price changes are influenced by supply and demand dynamics, macroeconomic uncertainty, and geopolitical factors; Studies Joëts et al. (2017) highlight how macroeconomic uncertainty variables are a key predictor of commodity price volatility. These findings reinforce the urgency of this research: this paper provides an integrated strategy framework combining the superior internal capabilities, strategy flexibility, and price risk management that are critical for mining companies in the face of global market volatility, maintaining profitability, and maintaining competitive advantages amid heightened uncertainty

The 2020–2024 period is a very relevant context to examine this phenomenon because it includes the disruption phases due to the COVID-19 pandemic, post-pandemic recovery, smelter capacity expansion, and sharp global commodity price volatility. To date, there has been no empirical research in Indonesia that specifically examines the role of commodity price volatility as a moderation variable in the relationship between operational efficiency and company size on EBITDA margin in the mining manufacturing sector. Therefore, this study aims to answer the question: *How does commodity price volatility moderate the relationship between operational efficiency (OCR) and company size to profitability (EBITDA margin) in mining manufacturing companies in Indonesia during the period 2020–2024?*

METHODS

This study uses a quantitative approach with secondary data in the form of annual financial statements of mining manufacturing companies listed on the Indonesia Stock Exchange (IDX) for the period 2020–2024, as well as main commodity price data obtained from The Pink Sheet Commodity Price Annual published by the World Bank. The study population

included all mining companies listed on the IDX during the study period which included 60 companies, while the sample was determined through purposive sampling techniques with the following criteria: consistently recorded during the observation period, issuing complete audited financial statements, having main activities in manufacturing or processing mining products, and not experiencing delisting or trading suspension in the long term. The sample obtained based on these criteria is 53 companies. The use of purposive sampling is considered appropriate because it allows researchers to select samples that are relevant to the research objectives and according to certain characteristics (Sekaran & Bougie, 2019).

The unit of analysis of this research is a company for a period of 5 years so that it produces panel data. The panel data method was chosen because it is able to combine cross-section and time series dimensions to provide richer information, increase the degree of freedom, and reduce the problem of multicollinearity in estimation (Baltagi, 2021). The analysis was carried out with E-Views software through several stages, namely the presentation of descriptive statistics to illustrate the distribution of data, the testing of the panel model using the Chow, Hausman, and Lagrange Multiplier tests to determine the best model (Gujarati & Porter, 2009), and the estimation of panel regression in both the basic model and the moderation model. Hypothesis testing is carried out through a t-test to test the significance of individual regression coefficients, an F test to assess the significance of the model as a whole, and a determination coefficient (R^2) to measure the proportion of variation in dependent variables described by independent and moderation variables (Wooldridge, 2016).

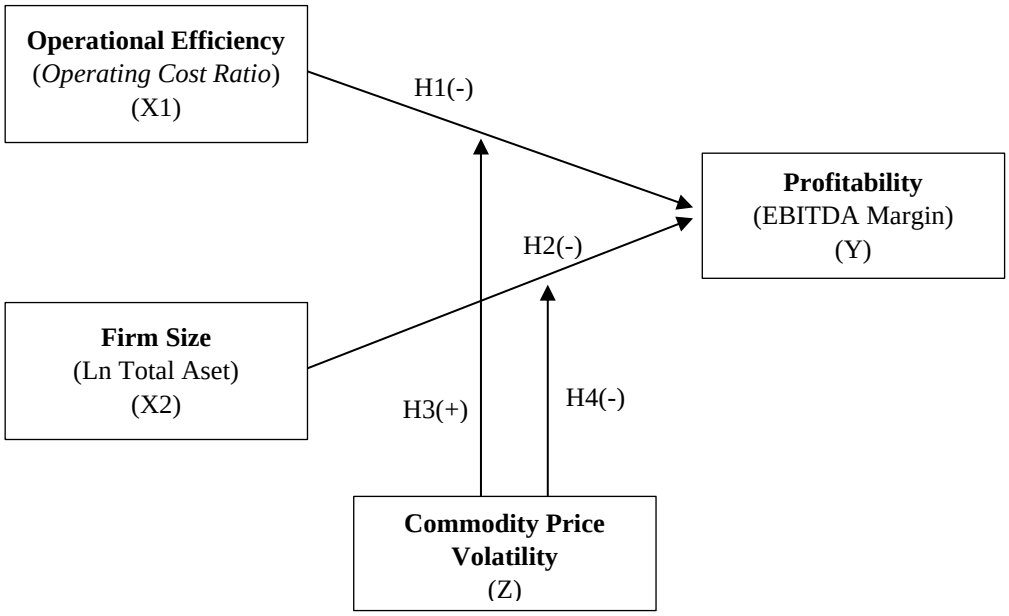


Figure 1. Conceptual Diagram

Based on the conceptual framework of research and previous studies, the research hypothesis can be formulated as follows:

H1: Operational efficiency has a significant negative effect on profitability.
H2: The size of the company has a significant negative effect on profitability.
H3: Commodity price volatility moderated (strengthens) the relationship between operational efficiency and profitability.
H4: Commodity price volatility moderated (weakens) the relationship between company size and profitability.

RESULTS AND DISCUSSION

Descriptive Statistic

Table 1. Statistical Descriptive Test Results

Variable	Obs	Minimum	Maximum	Mean	Std. Dev
Operating Cost Ratio	265	9.269	99.500	73.872	17.621
Firm Size	265	22.077	42.981	29.174	2.704
Profitability (EBITDA Margin)	265	60.790	25833.730	2092.526	94.537
Commodity Prices	265	5.625	69.727	27.940	14.460

Source: Processed Data using Ms. Excel

Table 1. shows the results of descriptive analysis for the variables used in this study. The Operating Cost Ratio (OCR) averaged 73,872, with a range between 9,269 and 99,500, as well as a standard deviation of 17,621, indicating a large variation in operational efficiency between companies. The average firm size is 29,174, with a range of 22,077 to 42,981, and a standard deviation of 2,704, indicating moderate variation in firm size. The average profitability (EBITDA Margin) was 2092,526, with a very wide range between 60,790 and 25833,730, as well as a standard deviation of 94,537, indicating a large difference in profitability levels. Lastly, the average Commodity Price is 27,940, with a range of 5,625 to 69,727, and a standard deviation of 14,460, reflecting significant fluctuations in commodity prices that affect the company's costs and profitability.

Overall, the results of this descriptive analysis show significant variation across the variables analyzed, reflecting differences in operational efficiency, company size, profitability, and dependence on commodity prices. This variation is important to analyze how these factors interact with each other in influencing a company's profitability.

Model Selection Test

To choose the most appropriate model in the analysis of panel data, a series of tests were carried out, namely the Chow Test, the Hausman Test, and the Lagrange Multiplier Test.

Chow Test

Table 2. Chow Test Results (EViews output)

Effect Test	d.f.	Prob
Cross-section F	(52,207)	0.0000
Cross-section Chi-square	52	0.0000

Source: Processed Data using EViews

The Chow test is used to determine between the Common Effect (CE) and Fixed Effect Model (FEM) models. Based on the results of the Chow test, the probability value obtained was 0.0000, which is smaller than the significance level of 0.05. Thus, the Fixed Effect Model (FEM) was chosen because it is better able to handle the constant individual heterogeneity between analysis units (e.g. firms), which cannot be explained by independent variables in the model. This is in line with the explanation by Baltagi (2021), who stated that FEM is the right choice when there are differences between companies that cannot be observed and are considered fixed throughout the observation period.

Hausman Test

Table 3. Hausman Test Results (EViews output)

Test Summary	Chi-sq. d.f.	Prob
Cross-section random	5	0.0000

Source: Processed Data using EViews

Next, the Hausman Test was performed to choose between a Fixed Effect Model (FEM) and a Random Effect Model (REM). The results of the Hausman test showed a probability value of 0.000, which is smaller than 0.05. Based on these results, the Fixed Effect Model (FEM) was chosen as a more efficient model. According to Wooldridge (2016), when the results of the Hausman test show a significant difference, the FEM model is selected, thus there is no need to perform the Lagrange Multiplier test.

Based on the results of both tests, the Fixed Effect Model (FEM) was chosen as the appropriate estimation model for this study, which effectively eliminates the bias of missing variables and time invariances, resulting in a more accurate and consistent estimate of the impact of independent variables.

Multicollinearity Test

Table 4. Multicollinearity Test Results (EViews output)

	X1	X2	Z	X1Z	X2Z
X1	1.000000	-0.066937	0.043265	0.716955	-0.013056
X2	-0.066937	1.000000	-0.133720	-0.159475	0.348948
Z	0.043265	-0.133720	1.000000	0.708555	0.785542
X1Z	0.716955	-0.159475	0.708555	1.000000	0.575672
X2Z	-0.013056	0.348948	0.785542	0.575672	1.000000

Source: Processed Data using EViews

Based on the results of the multicollinearity test presented in Table 4, it can be concluded that there are no serious multicollinearity problems in the regression model used. Correlation values between independent variables indicate that most correlation coefficients are at low to moderate levels. Although there are some relatively higher correlations, such as between the volatility variable (Z) and the interaction X1Z (0.709) and between Z and X2Z (0.786), overall there is no correlation coefficient that exceeds a critical value of 0.8 indicating severe multicollinearity. Thus, the regression model used has met the free assumptions of multicollinearity and the resulting parameter estimation is reliable for further analysis.

Heteroscedasticity Test

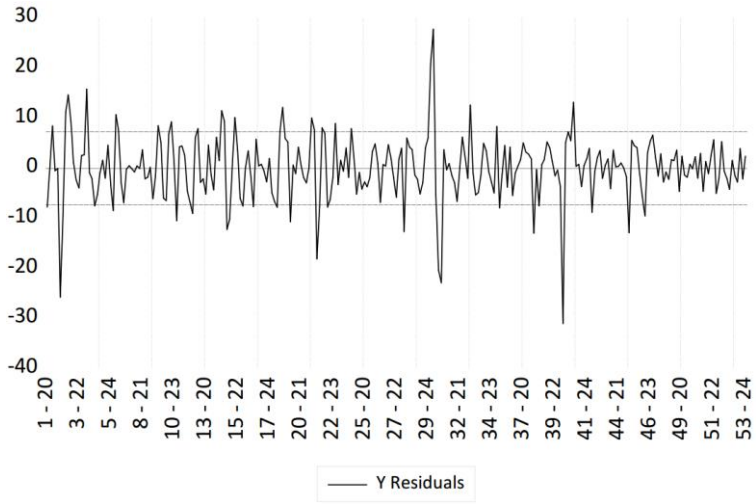


Figure 1. Residual Heteroscedasticity Test Results (EViews output)

Source: Processed Data using EViews

The results of the heteroscedasticity test shown in Figure 1 show that the residual model is randomly dispersed and does not form a specific pattern around zero. This unsystematic pattern of residual distribution indicates that there is no heteroscedasticity problem in the model. The visualization of residual plots versus fitted values shows randomly scattered residual points both above and below the zero line, without forming a clear pattern such as clustering, spreading, or narrowing. With the fulfillment of this assumption of homogeneity, the regression model used has fulfilled one of the important assumptions in linear regression so that the results obtained are the best linear unbiased estimator (BLUE).

Based on these two tests, it can be concluded that the panel data regression model used in this study has met the classical assumptions of multicollinearity and heteroscedasticity, so that the results of the estimation and interpretation carried out can be statistically accounted for.

Panel Data Regression Equation

In this study, the regression equations obtained from the EViews output for the panel data model used to analyze the effect of commodity price volatility moderation on the relationship between Operating Cost Ratio (OCR) and Firm Size on Profitability (EBITDA Margin) are as follows:

$$\mathbf{Y_{it} = \beta_0 - \beta_1 X_{1,it} + \beta_2 X_{2,it} + \beta_3 Z_{it} + \beta_4 (X_{1,it} \times Z_{it}) - \beta_5 (X_{2,it} \times Z_{it}) + u_{it}}$$

$$\mathbf{Y = 22.1615 - 0.2526*X_1 - 0.4645*X_2 + 14.0463*Z - 0.0167*X_1Z - 0.3779*X_2Z + (CX=F)}$$

Constant (β_0 = 22.1615): A constant value of 22.1615 indicates an average Profitability (EBITDA Margin) of 22.16% when all independent variables, including moderation variables, are considered to be zero. In this context, this is the company's basic level of profitability.

Operational Cost Efficiency Coefficient (X_1 = -0.2526): The regression coefficient for the Operating Cost Ratio (OCR) variable is negative and significant of -0.2526. This confirms that operational efficiency has a direct negative effect on profitability. Any increase of one unit of OCR (which signifies a decrease in efficiency), will decrease the EBITDA Margin by 0.25 units, assuming the other variables are constant. These findings are in line with the theory that high operating costs will eat into the company's profits.

Firm Size Coefficient (X_2 = -0.4645): The regression coefficient for the Firm Size variable is also negative at -0.4645. This means that the size of the company directly negatively impacts profitability. Every increase of one unit in the size of the company is followed by a decrease in profitability by 0.46 units, ceteris paribus. This result can indicate a diseconomies of scale, where large companies face bureaucratic inefficiencies or managerial complexity that suppress profitability.

Commodity Price Volatility Coefficient (Z = 14.0463): The coefficient for the Volatility moderating variable (Z) itself is positive and quite large, which is 14.0463. This shows that, directly, commodity price volatility has a strong positive influence on profitability. In volatile conditions, there is an opportunity to make higher profits, perhaps through a quick price adjustment mechanism or trading activity.

Effect of Volatility and Operational Efficiency Interaction (X_1Z = -0.0167): The interaction coefficient between OCR and Volatility is negative (-0.0167). This value reinforces the interpretation of the previous t-test. The negative interaction between X_1 and Z means that the negative influence of OCR (poor efficiency) on profitability becomes stronger when volatility is high. In other words, volatility does not succeed in moderating the negative effects of OCR; On the contrary, volatility exacerbates the impact of these operational inefficiencies. In a volatile environment, companies with high operating costs will experience heavier profitability pressures.

Effect of Volatility and Company Size Interaction (X_2Z = -0.3779): The interaction coefficient between Firm Size and Volatility is also negative (-0.3779). This confirms that volatility reinforces the negative influence of company size on profitability. This negative

interaction indicates that in volatile situations, the scale advantage (Firm Size) turns into a burden. Large companies become less agile and more difficult to adapt to rapid market changes compared to smaller companies, so their profitability is further negatively impacted.

Overall, this regression equation reveals an interesting narrative. Although volatility can directly increase profitability, it acts as a reinforcer of negative factors in the company. Volatility exacerbates the impact of operational inefficiencies and large-scale ineffectiveness. The main policy implication of these findings is that in the face of commodity price volatility, companies' top priorities should be to aggressively improve operational efficiencies and review their scale-up growth strategies to become more agile and adaptive.

Adjusted R-Square

Table 5. Result of the R-Square Coefficient (EViews output)

Variable	Adjusted R-square	Description
Profitability	0.746	Strong

Source: Processed Data using EViews

The test results show that the Adjusted R^2 of 0.746 means that approximately 74.6% of the variation in profitability (EBITDA Margin) can be explained by independent variables in the model, namely operational efficiency, company size, commodity price volatility, and interaction variables (moderation). Thus, only about 25.4% of the variation in profitability is explained by factors outside the model, such as managerial factors, capital structure, macroeconomic conditions, and global market dynamics.

This high Adjusted R^2 value indicates that the model has a very strong explanatory power, so it can be relied upon to describe the relationships between the study variables. According to Gujarati & Porter (2009), the value of Adjusted R^2 close to 1 shows that the regression model has a good goodness of fit and is relevant in explaining the variation of dependent variables. Widarjono (2018) also emphasized that the use of Adjusted R^2 is more appropriate than ordinary R^2 in the panel data model because it has corrected the bias due to the number of independent variables.

Furthermore, Verbeek (2017) explains that Adjusted R^2 is important for evaluating model quality in the context of panel regression, as it reduces the possibility of overestimation of conventional R^2. This is also supported by Baltagi (2021) who states that the high Adjusted R^2 value in the Fixed Effect model shows that the random variables and covariates chosen have reflected substantive variations between cross-section and time series units.

Empirically, several studies have also found high Adjusted R^2 values in studies of the profitability of the mining and energy sectors. For example, T. Khan et al. (2024) found Adjusted $R^2 > 0.80$ when analyzing the determinants of profitability of mining companies in South Asia. Li & Liu's (2021) research also shows that commodity price volatility is able to explain most of the variation in energy companies' profitability, with an Adjusted R^2 of more than 0.85.

Hypothesis Tests

t Test

The use of the t-test in this study is in accordance with the objective of testing four hypotheses involving the influence of operational efficiency (OCR), company size, and commodity price volatility on profitability (EBITDA Margin). The t-test makes it possible to statistically test whether changes in these independent variables contribute significantly to changes in the dependent variables, which in this case is the EBITDA Margin.

Table 6. t Test Results (EViews output)

Variable	t-Statistic	t-Value	Prob	Description
X1 (Operating Cost Ratio)	-2.982	1.969	0.021	Operational efficiency decrease profitability (-)
X2 (Firm Size)	-1.975		0.008	Company size decrease profitability (-)
X1Z (Interaction X1*Z ⟶ Y)	2.665		0.036	Volatility strengthens the influence of operational efficiency on profitability (+)
X2Z (Interaction X2*Z ⟶ Y)	-1.992		0.026	Volatility weakens the influence of company size on profitability (-)

Source: Processed Data using EViews

The results of the t-test analysis showed a significant influence of independent variables on profitability (EBITDA Margin).

H1 (Operational Efficiency → Profitability): Negative and statistically significant coefficient values (t-statistically = -2.982; p-value = 0.021 < 0.05) indicate that an increase in the Operating Cost Ratio (X1) is associated with a decrease in profitability. In other words, low operational efficiency (indicated by a high operating expense ratio) significantly lowers the company's profitability.

H2 (Firm Size → Profitability): Negative and significant coefficient values (t-statistic = -1.975; p-value = 0.008 < 0.05) indicate that Company Size (X2) has a negative effect on profitability. These results imply that companies with larger sizes tend to have lower levels of profitability in the context of this study.

H3 (Moderation of Volatility in the relationship between Efficiency → Profitability): Positive and significant interaction values (t-Statistics = 2,665 > t-Table 1,969; p-value = 0.036 < 0.05) reveal that volatility (Z) moderates the effect of operational efficiency on profitability. Specifically, volatility amplifies the positive influence of operational efficiency. In a volatile environment, companies with high operational efficiency are able to take advantage of these conditions to increase profitability more significantly.

H4 (Volatility Moderation in the relationship of Size → Profitability): Negative and significant interaction values (t-Statistically = -1.992; p-value = 0.026 < 0.05) indicate that volatility (Z) also moderates the relationship between firm size and profitability, but in a debilitating direction. This means that in volatile conditions, the advantages possessed by large companies are not effective in driving profitability, or even tend to reduce profitability.

Overall, these findings confirm that the two main independent variables (operational efficiency and company size) directly negatively affect profitability. However, the role of volatility as a moderator proved significant. Volatility reinforces the positive influence of operational efficiency, while also weakening the negative influence of company size on profitability. The implication is that, in a volatile business environment, maintaining operational efficiency is a more critical factor for profitability than simply relying on the scale or size of the company.

F Test

Table 7. F Test Results (EViews output)

Variable	F-Statistic	F-Table	Prob	Description
(X1, X2, X1Z, X2Z) ⟶ Y	14.643	2.249	0.000	Simultaneously, independent variables have a significant effect on profitability (EBITDA Margin))

Source: Processed Data using EViews

The results of the F test show that the F-statistic = 14.643 is greater than the F-value = 2.249, which causes H_0 to be rejected. This means, simultaneously, that independent variables, namely operational efficiency, company size, commodity price volatility, and their interactions have a significant effect on profitability (EBITDA Margin). The implication of these findings is that the regression model used has proven to be statistically accurate to explain the relationship between these variables and profitability. All four independent variables have very strong predictive power against variations in EBITDA Margin, suggesting that the model can effectively explain the factors that affect profitability. The much larger F-calculated values of the F-table also indicate that the model has a high goodness of fit, which means that the model is excellent at describing variations in data and predicting the profitability of the company (Gujarati & Porter, 2009; Widarjono, 2018).

Discussion

The Effect of Operational Efficiency on Profitability (EBITDA Margin)

The results of the t-test prove that Operating Cost Ratio (OCR) has a negative and significant effect on Profitability (EBITDA Margin) with a t-statistical value of -2.982 and a probability of 0.021. These findings confirm that the increase in the operating expense ratio has direct implications for a decrease in the company's profitability, as shown by the t-calculated value that exceeds the critical value.

Theoretically, these findings are consistent with the Resource-Based View (Wernerfelt, 1984; Barney, 1991;) which emphasize operational efficiency as a strategic resource to create a competitive advantage. In addition, Agency Theory (Jensen & Meckling, 1976) explains that optimal cost efficiency can minimize conflicts of interest between managers and shareholders.

In the specific context of Indonesia's mining and manufacturing industries, these findings reflect complex structural challenges. Downstream policies and Domestic Market Obligations (DMOs) create significant operational cost pressures, while divestment regulations have the potential to disrupt operational continuity and increase transaction costs. The uncompetitive structure of domestic energy costs further aggravates the company's operational burden.

This research is reinforced by previous empirical findings. The study of Suhendar et al. (2024) confirms that high operating costs negatively impact profit margins in the manufacturing and mining sectors. Similarly, the research of Batugina et al. (2020) showed a negative relationship between operating costs and profitability stability. Li & Liu (2021) emphasized that operational efficiency is a key factor in the company's resilience in the face of market fluctuations.

However, this relationship shows a more complex dynamic in the presence of moderation variables. Commodity price volatility has been shown to strengthen the influence of operational efficiency on profitability, as shown by the t-statistical value of 2,665 for the interaction variable. This indicates that in a volatile environment, companies with high operational efficiency actually have better resilience in maintaining profitability.

Thus, controlling operational costs not only determines profitability, but also serves as a buffer against external shocks in cyclical industries such as mining. These findings reinforce the importance of optimizing operational efficiencies in the company's strategy to deal with complex regulatory and market dynamics in Indonesia.

The Effect of Company Size on Profitability (EBITDA Margin)

The results of the t-test showed that the size of the company had a negative and significant effect on profitability with a t-statistical value of -1.975 and a probability of 0.008. These findings indicate that in the context of this study, companies with larger sizes tend to experience a decrease in profitability.

Theoretically, this finding can be explained through the concept of diseconomies of scale (Modigliani & Miller, 1958) where the high operational complexity of large-scale companies

actually creates cost inefficiencies. The Resource-Based View perspective (Barney, 1991) also provides an explanation that the resources owned by large companies cannot always be transformed into competitive advantages without adequate managerial capabilities.

In the specific context of Indonesia's mining and manufacturing industry, this phenomenon can be understood through several mechanisms. First, the Domestic Market Obligation (DMO) policy and downstream requirements place a heavier burden on large companies, where the allocation of production for domestic needs at controlled prices reduces the realization of potential revenue. Second, divestment regulations create uncertainty of ownership and governance that can disrupt the operational efficiency of large-scale companies.

These findings have gained support from several empirical studies. Research by Rachmawati & Triyono (2021) confirms that there is an optimal point where company expansion actually turns to reduce profitability. A study by Sun et al. (2024) shows that the size of a company without being balanced by adequate managerial capabilities can be a burden rather than an advantage.

However, the dynamics of this relationship become more complex with the presence of moderation variables. Commodity price volatility has been shown to weaken the influence of company size on profitability, as shown by the t-statistical value of -1,992 for the interaction variable. This indicates that in conditions of high volatility, the company's scale advantage is not effective enough in maintaining profitability.

Thus, these findings provide a new perspective that firm-scale excellence is not always linear contributing to increased profitability, especially in a complex regulatory and market environment like Indonesia. The implication is that a company's growth strategy needs to consider aspects of efficiency and managerial capabilities, not just scale expansion.

The Role of Commodity Price Volatility Moderation on the Effect of Operational Efficiency on Profitability (EBITDA Margin)

The results of the H3 hypothesis test show that commodity price volatility significantly strengthens the positive relationship between operational efficiency and profitability (EBITDA Margin), with a t-value of 2,665 confirming the significance and magnitude of the influence of moderation. These findings underscore that the strategic value of operational efficiency is contextual and highly dependent on external conditions.

Theoretically, these results have strong support from the Resource-Based View (RBV) and Dynamic Capabilities theory (Teece, 2007; Teece et al., 2016). Price volatility, as an external shock that increases uncertainty (Abaidoo & Agyapong, 2022), transforms operational efficiency from a mere competitive advantage to a critical capability for survival. Under these conditions, the ability to minimize waste and optimize costs serves as a buffer that absorbs price shocks, so that efficient companies are not only able to maintain margins but also gain advantages relative to less efficient competitors. Volatility thus increases the return of investment in building operational efficiencies.

These findings align with a body of cutting-edge empirical research exploring the interaction between internal and external factors. Liu et al. (2024) research on the Australian mining sector and Sun et al. (2024) both confirm that operational efficiency serves as an effective "shield" during periods of commodity price volatility, where its positive impact on profitability becomes much stronger.

However, literature also provides nuance. The study of Mensi et al. (2021) indicates that the type of volatility has an effect, with demand-side shock-driven volatility providing greater benefits to efficient companies than supply-side shocks. These results reinforce Smith et al. (2024) argument that in the commodity industry, operational risk management that is centered on efficiency is just as important as financial risk management. Thus, this study not only supports the previous findings but also confirms that volatility plays a role as a mechanism that clarifies the fundamental competency differences between firms.

The Role of Commodity Price Volatility Moderation on the Effect of Company Size on Profitability (EBITDA Margin)

The results of the fourth hypothesis (H4) test revealed a counter-intuitive but significant finding: commodity price volatility has been shown to weaken the positive relationship between company size and profitability (EBITDA Margin). A negative t-count value of -1,992 that exceeds the critical t-value (1,969) indicates that in a volatile environment, the scale advantage of large companies turns into vulnerability.

These findings derive a strong theoretical foundation from the concept of Organizational Rigidity and the theory of Core Rigidities. Smith et al. (2024) revealed that as the scale and complexity of operations increase, large companies tend to develop rigid bureaucratic structures, hierarchical and slow decision-making processes, and deep commitments to asset specificity and high fixed costs. In stable market conditions, this structure supports efficiency. However, in the midst of volatility in commodity prices that require a quick and flexible response, the same structure is actually a liability. This rigidity hinders the company's ability to adapt agilely, adjust procurement strategies, or switch to cheaper alternative inputs quickly.

Furthermore, the theory of Dynamic Capabilities (Teece, 2007) provides a complementary explanation. This theory distinguishes between ordinary capabilities (such as operational efficiency under routine conditions) and dynamic capabilities (the ability to integrate, build, and reconfigure resources to deal with changing environments). The size of a large company may correlate with strong capabilities, but it does not automatically guarantee having strong dynamic capabilities. Commodity price volatility is a test for dynamic capabilities, namely the ability to transform and reconfigure. Large, rigid companies have a harder time doing this, so they suffer more in uncertainty than small, agile companies that are able to turn around faster. Thus, volatility acts as a mechanism that separates large "agile" (ambidextrous) companies from large "rigid" ones.

The findings of this study are in line with the development of the latest literature that begins to criticize the absolute advantages of large scale (big is beautiful) and highlight its dark side (the liability of bigness) in the context of uncertainty. Research by Wang (2024) on manufacturing companies in West Africa found that during periods of commodity crisis, medium-sized companies with lean structures actually showed better profitability resilience than large conglomerates. Their study concluded that bureaucracy and high overhead costs at large companies become a critical burden when revenues are eroded by falling prices. Similarly, T. Khan et al. (2024) in cross-industry research reported that company size is negatively correlated with strategic agility, which is a key predictor of performance in volatile times.

However, literature also provides important nuances. A study by A. Khan et al. (2024) argues that not all large companies are vulnerable. They found that large companies that have a decentralized organizational design, adopt digital technologies to increase agility, and actively manage their commodity risk portfolios (such as through hedging), can instead leverage volatility to strengthen their dominant positions. These findings are consistent with dynamic capabilities theory, which emphasizes resource configuration, not just size.

The contribution of this study to the existing literature is to provide clear quantitative evidence that volatility can reverse the usually positive relationship between size and profitability. These results reinforce the view of Teece et al. (2016) that in a highly turbulent environment, the "scale advantage" should be reviewed and replaced with an "agility advantage". Thus, this study not only confirms the existence of liability of bigness but also identifies the specific condition i.e. commodity price volatility where this vulnerability is most clearly manifested.

CONCLUSION

Based on the comprehensive analysis conducted, it can be concluded that navigation in dealing with commodity price volatility is a critical determinant of the profitability of mining manufacturing companies in Indonesia. This study has succeeded in proving that internal capabilities, namely operational efficiency and company size, are significant drivers of profitability. However, its effectiveness is greatly moderated by the external environment in the form of price volatility. The findings confirm that high operational efficiency serves as a strong protector, where its positive impact on profitability is significantly strengthened during periods of high volatility. Instead, the advantages that are usually inherent in the size of large companies can turn into vulnerabilities in turbulent markets, as volatility weakens the relationship between size and profitability.

The practical implications for the industry are the importance of prioritizing operational flexibility and a robust risk management strategy over just expansion. Ultimately, the study confirms that in the face of commodity uncertainty, strategic resilience rooted in efficiency and adaptability is much more valuable to sustain sustainable profitability.

However, these findings need to be seen in the context of some limitations. First, the scope of the research is limited to a 5-year period (2020-2024) which may not fully capture the complete commodity cycle. Second, the sample is limited to 53 companies publicly traded on the IDX, so the findings may not fully represent the entire population of mining and manufacturing companies in Indonesia. Third, volatility measurements conducted in aggregate may not reflect the specific dynamics of the different commodities produced by each company.

Based on these limitations, the future research can conducting an analysis based on specific commodity groups (minerals, coal, oil and gas) to understand the dynamics in more detail. Include additional moderation variables such as hedging activity or capital intensity in the research model and apply more complex volatility measurement methods such as the GARCH model to capture time-varying volatility characteristics. Fourth, expand the scope of the sample by including non-public companies to get a more comprehensive insights.

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