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Robust Standard Error Panel Regression of Firm Size, Leverage, Profitability on Firm Value: Indonesian Mining 2022–2024

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Abstract:

This study analyzes the effects of firm size, leverage (DER), and profitability (ROA) on firm value (PBV) using panel data regression with robust standard error correction. Data were collected from 21 Indonesian mining sector companies listed on the IDX from 2022–2024 (63 observations). Based on the Chow test (p=1.46E-09) and Hausman test (p=0.002), the Fixed Effects Model was selected. Classical assumption tests revealed violations of heteroskedasticity (p=0.029) and autocorrelation (p=0.005), so cluster-robust standard errors (clustering by time) were applied. The results show that all three variables simultaneously affect firm value (p=0.0538). Partially, firm size has a significant negative effect (coef. -0.481; p=0.038), leverage has a significant positive effect (coef. 0.672; p=0.018), and profitability shows a marginally significant negative effect (coef. -0.796; p=0.092). The R-squared of 17.6% indicates other influencing factors. In conclusion, the post-pandemic Indonesian mining market responds negatively to large assets and high profitability but positively to increased debt. Investors should focus on optimal debt structures rather than short-term profitability, and managers must reconsider asset expansion strategies.

1. Introduction

Firm value is a fundamental indicator that reflects a company's performance and prospects in the eyes of stakeholders, particularly investors. In the context of the capital markets, a high firm value signals the company's ability to generate future profits. One of the most commonly used ratios to measure firm value is the Price-to-Book Value (PBV) ratio, which indicates how much the market values a company's equity relative to its book value (Fama & French, 1998). A high PBV indicates that investors have positive expectations regarding the company's growth and performance. The manufacturing sector plays a strategic role in Indonesia's economy as a sector that makes a significant contribution to Gross Domestic Product (GDP) and employment. According to data from the Central Statistics Agency (BPS), the manufacturing sector has contributed approximately 18–20% to national GDP over the past five years. However, the performance of manufacturing sector stocks has shown considerable volatility, reflected in the variation in PBV values across companies. Data compiled from the Indonesia Stock Exchange (IDX) indicates a significant disparity in PBV values among manufacturing companies, with some companies having a PBV more than three times their book value, while others have a PBV below 1. This phenomenon raises fundamental questions regarding the factors causing these differences in market valuation of these companies, thereby highlighting the need for more in-depth research on the determinants of firm value.

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Research on the factors influencing firm value has been extensively conducted in both developed and emerging capital markets, drawing on various theoretical frameworks. Signaling theory (Ross, 1977) explains that information about a company's performance published in financial statements sends signals to the market, which in turn affects stock prices. Trade-off theory (Kolari & Velez-Pareja, 2010) explains that an optimal capital structure can increase a company's value through the tax benefits of debt. Meanwhile, agency theory (Jensen & Meckling, 1976) highlights potential conflicts of interest between management and shareholders that could affect a company's value. In terms of company size, the research findings reveal significant inconsistencies. Some studies have found that large companies tend to have higher values due to greater stability and better access to capital (RAJAN & ZINGALES, 1995), However, other studies show that small companies have higher growth potential and are therefore valued at a premium by the market (Fama & French, 1998). The leverage variable, proxied by the debt-to-equity ratio (DER), also yields mixed results. Some studies support the view that leverage increases firm value by reducing the tax burden (Kolari & Velez-Pareja, 2010; Pratama & Widyastuti, 2022), Meanwhile, other studies have found that high leverage actually reduces a company's value by increasing the risk of bankruptcy and agency costs (Jensen & Meckling, 1976; Kotler et al., 2021). Profitability, as measured by Return on Assets (ROA), has shown greater consistency as a predictor of firm value, with most studies confirming that profitability has a positive impact on PBV, which aligns with signaling theory—that high profits send a positive signal to the market (Ross, 1977; Sudana et al., 2020).

Although extensive research has been conducted on the factors influencing firm value, there are several gaps that need to be addressed. First, most previous studies have used relatively short observation periods or cross-sectional data, and thus have not fully captured the dynamics of changes in firm value over time. Second, the use of different analytical methods yields varying findings, yet few studies comprehensively compare panel data estimation models and address potential violations of classical assumptions such as Heteroskedasticity and autocorrelation. Third, research on PBV in Indonesia remains limited to specific sectors with relatively small sample sizes, so the generalizability of the findings still needs to be tested. Based on the identification of these gaps, this study aims to analyze the effects of firm size (Size), leverage (DER), and profitability (ROA) on firm value, proxied by PBV, among manufacturing firms listed on the Indonesia Stock Exchange. The novelty of this study lies in the use of a panel data regression approach with a three-year observation period (2022–2024), which allows for a more accurate capture of intertemporal and inter-individual variations, as well as the use of robust standard errors to address potential heteroscedasticity and autocorrelation resulting from extreme volatility in the data, thereby yielding better estimates. This study is expected to contribute to investors in making investment decisions, to company management in formulating strategies to increase corporate value, and to academics as a reference for further research in the field of financial management.

2. Literature Review

2.1. Panel Data Regression Analysis

Panel data regression is an econometric analysis method that combines cross-sectional data (across individuals/units) and time-series data (across time). Panel data allows researchers to control for unobserved heterogeneity that remains constant over time (Baltagi, 2015). A general panel data regression model can be expressed as follows

,

$$Y_{it} = \beta_{0it} + \beta X_{kit} + \varepsilon_{it} \quad (1)$$

Where,

Y_{it} : The value of the $i-th$ individual's dependent variable for the $t-th$ period; $i = 1,2,3,\dots,N$ and $t = 1,2,3,\dots,T$

β : Estimated parameters

X_{kit} : The value of the $k-th$ independent variable for the ith individual in the $t-th$ year

ε_{it} : error for the $i-th$ individual in the $t-th$ period

2.2. Model Regresi Data Panel

In general, panel data regression can be performed using three approaches, namely (Baltagi, 2015), 2.2.1 *Random Effect Model*

In the random-effects model, differences in individual and time characteristics are accounted for in the model's error term. Since there are two components contributing to the error term—individual and time—the random error in the random-effects model must also be decomposed into a time-component error and a combined error. The random-effects model is written as follows (Srihardianti et al., 2016)

$$Y_{it} = \beta_0 + \beta X_{kit} + u_{it} + \varepsilon_{it} \quad (2)$$

Where,

Y_{it} : The value of the $i-th$ individual's dependent variable for the $t-th$ period; $i = 1,2,3,\dots,N$ and $t = 1,2,3,\dots,T$

β : Estimated parameters

X_{kit} : The value of the $k-th$ independent variable for the ith individual in the $t-th$ year

u_{it} : Error for the $i-th$ individual in the $t-th$ period

ε_{it} : Error for the $i-th$ individual in the $t-th$ period

2.2.2 *Fixed Effect Model*

The fixed-effects model for panel data assumes that the slope coefficients for each variable are constant, but the intercepts differ across cross-sectional units. To distinguish the intercepts, dummy variables can be used, so this model is also known as the Least Square Dummy Variable (LSDV) model. The estimation technique for panel data regression models using the fixed-effects model with the Least Square Dummy Variable (LSDV) approach is as follows (Hutagalung & Darnius, 2022).

$$Y_{it} = \beta_{0it} + \beta X_{kit} + \varepsilon_{it} \quad (3)$$

Where,

Y_{it} : The value of the $i-th$ individual's dependent variable for the $t-th$ period; $i = 1,2,3,\dots,N$ and $t = 1,2,3,\dots,T$

β : Estimated parameters

X_{kit} : The value of the $k-th$ independent variable for the ith individual in the $t-th$ year

ε_{it} : Error for the $i-th$ individual in the $t-th$ period

2.2.3 *Common Effect Model*

The common-effects model for panel data assumes that the intercept and slope values for each variable are the same across all cross-sectional units and time series. This model structure is often referred to as pooled regression. The general form of the common-effects approach is as follows (Hutagalung & Darnius, 2022)

$$Y_{it} = \beta_0 + \beta X_{kit} + \varepsilon_{it} \quad (4)$$

Where,

Y_{it} : The value of the $i-th$ individual's dependent variable for the $t-th$ period; $i = 1,2,3,\dots,N$ and $t = 1,2,3,\dots,T$

β : Estimated parameters

X_{kit} : The value of the $k-th$ independent variable for the ith individual in the $t-th$ year

ε_{it} : Error for the $i-th$ individual in the $t-th$ period

2.3. Panel Data Regression Model Selection

When selecting a panel data regression model to determine the best model, three tests can be used, namely

2.3.1 Chow Test

The Chow test, also known as the likelihood ratio test, can be used to choose between two models in panel data regression: the Fixed Effects Model (FEM) and the Common Effects Model (CEM). This test can be conducted by examining the significance of the FEM using the F-statistic
(Hidayat et al., 2018).

$$F_{hitung} = \frac{\frac{RSS_1 - RSS_2}{K-1}}{\frac{RSS_2}{KT-K-P}} \sim F\big(\alpha, (K-1), (KT-K-P)\big) \quad (5)$$

Where,

K : Number of Sectors

T : Observation Period

P : Number of parameters in the fixed-effects model

RSS_1 : Residual sum of squares for the common effects model

RSS_2 : Residual sum of squares for the fixed-effects model

If the calculated F-value is greater than the critical $F_{value} > F_{Table}\ F(\alpha, (K-1), (KT-K-P)$ at a given α, then the selected model is the FEM model.

2.3.2 Hausman Test

This test is used to choose between the Random Effects Model (REM) and the Fixed Effects Model (FEM). It is used to test whether there is a relationship between the model residuals and one or more explanatory (independent) variables in the model. The null hypothesis is that there is no relationship between the model residuals and one or more explanatory variables. Following the Wald criteria, the Hausman statistic will follow a chi-square distribution as follows

$$W = \chi^2_{(p)} = [b-\beta]'\Psi^{-1}[b - \mathrm{B}]$$

Where, (6)

$$\Psi = Var[b] - Var[\beta]$$

Whith,

b : Random-effects parameter (without intercept)

β : Fixed-effect parameters using LSDV

$Var[b]$: Covariance matrix of the random effect parameters (without intercept)

$Var[\beta]$: Covariance matrix for fixed-effect parameters

If the value of $W > \chi^2_{(\alpha,P)}$, then the selected model is the FEM model. P is the number of independent variables.

2.3.3 *Lagrange Multipier Test*

The Lagrange Multiplier test is used to test for random effects based on the residuals from the common-effects model. The LM test statistic can be calculated using the following formula:

$$LM = \frac{KT}{2(T-1)}\left[\frac{\Sigma_{i=1}^{K}[\Sigma_{t=1}^{T} e_{it}]^2}{\Sigma_{i=1}^{K}\Sigma_{t=1}^{T} e_{it}^2} - 1\right]^2 \sim \chi^2_{\alpha,1} \quad (7)$$

Where,

K : Number of Sectors

T : Number of Time Periods

e_{it} : Residual model *common effects*

If $LM > \chi^2_{\alpha,1}$, then the selected model is the REM model.

2.4. Selection of a Robust Panel Data Regression Model

In panel data analysis, robust standard error estimates are necessary when classical assumptions such as Heteroskedasticity and autocorrelation are violated. There are several approaches to robust standard errors, namely:

2.4.1 Heteroskedasticity-Robust Standard Errors

Heteroskedasticity-Robust Standard Errors is a method for estimating standard errors that does not rely on the assumption of homoscedasticity. The formula used is as follows (Arellano, 1987; Colin Cameron & Miller, 2015)

$$\hat{V}_{HC} = \frac{N}{N-k}(X'X)^{-1}(\Sigma_{i=1}^{n} X_i' \hat{u}_i^2 X_i)(X'X)^{-1} \quad (8)$$

With,

N : Number of Observations
k : Number of Parameters
$\hat{u}_i$: Residuals from Ordinary Least Squares estimation
X_i : The vector of independent variables for the $i-th$ observation

2.4.2 *Cluster-Robust Standart Error*

Cluster-Robust Standard Errors is a method for estimating standard errors that is robust to Heteroskedasticity as well as to within-cluster and time-period correlations. The formula used is as follows (Arellano, 1987; Colin Cameron & Miller, 2015)

$$\hat{V}_{C} = (X'X)^{-1}(\Sigma_{i=c}^{C} X_c' \hat{u}_c^2 X_c)(X'X)^{-1} \quad (9)$$

With,

$\hat{u}_c$: Residuals from Ordinary Least Squares estimation
X_c : The vector of independent variables for the $c-th$ observation

2.5. Model Assumption Testing

Classical assumption testing is used to determine whether the model being used is appropriate. The classical assumption tests used are Test for normality using the Jarque-Bera test statistic, Test for multicollinearity using the Variance Inflation Factor (VIF), Test for Heteroskedasticity using the Glejser test., Autocorrelation test using the Durbin-Watson statistic.

3. Research Methodology

This study uses secondary data in the form of annual financial reports from manufacturing companies listed on the Indonesia Stock Exchange (IDX). The study period spans three years, from 2022 to 2024. The sample was selected using purposive sampling with the following criteria: manufacturing companies that presented complete financial statements during the study period, and the data required for the research variables were available. Based on these criteria, a sample of 21 companies was obtained, resulting in a total of 63 observations (21 companies × 3 years). The data were obtained from financial statements published on the official websites of the IDX and the respective companies.

3.1. Operational Definition of a Variable

3.1.1 Firm Size (X_1)

Firm size can generally be defined as a measure used to classify companies by size based on various factors, including total assets, average total assets, market capitalization, total sales/revenue, average sales, net income, number of employees, and others. (Dang et al., 2018).

The most commonly used metric is the natural logarithm of total assets, which is used to normalize asset data with very large values.

$$Company\ Size = \ln(Total\ Assets) \tag{10}$$

3.1.2 Leverage (X_2)

The leverage ratio is a measure used to evaluate the extent to which a company utilizes borrowed funds. This ratio helps identify the degree to which a company relies on debt in its financial structure. The leverage ratio used in this study is the Debt-to-Equity Ratio. This ratio measures the amount of a company's debt relative to its equity. This ratio provides an indication of the company's level of dependence on debt. The higher this ratio, the greater the company's use of debt (Dr. Kasmir, 2019). The formula for the DER is,

$$DER = \frac{Total\ Debt}{Total\ Equity} \tag{11}$$

3.1.3 Profitability (X_3)

Profitability is a company's ability to generate profit or earnings over a specific period. This ratio reflects the effectiveness and efficiency of management in managing the company's resources. The profitability metric used is Return on Assets (ROA). ROA is used to measure a company's ability to generate net profit relative to its total assets (Hery, 2015). The formula for ROA is,

$$ROA = \frac{Net\ Income}{Total\ Assets} \tag{12}$$

3.1.4 Firm Value (Y)

Firm Value is investors' perception of a company's level of success, which is often linked to its stock price. Firm value reflects a company's performance and its future growth prospects. The firm value metric used here is Price-to-Book Value (PBV). PBV is used to compare a stock's market price with its book value per share. If $PBV > 1$, it indicates that the market values the company higher than the value of its assets. (Dang et al., 2018).

$$PBV = \frac{Stock\ Price\ per\ Share}{Book\ Value\ per\ Share} \tag{13}$$

3.2. Hypothesis Testing

3.2.1. Firm Size (X_1)

H_0 : The Firm Size variable does not have a significant effect on Firm Value.
H_1 : The Firm Size variable has a significant effect on Firm Value.

3.2.2. Leverage (X_2)

H_0 : The leverage variable does not have a significant effect on firm value.
H_1 : The leverage variable has a significant impact on firm value.

3.2.3. Profitability (X_3)

H_0 : The Profitability variable does not have a significant effect on Firm Value.
H_1 : The Profitability variable has a significant impact on Firm Value.

4. Results and Discussion

4.1. Descriptive Statistics

Descriptive statistics are used to describe or provide a general overview of the characteristics of each object under study. The descriptive statistics for each variable are as follows:

Table 1. Descriptive Statistics of the Research Data

Variable	Year	Mean	Median	Min	Max	Std.Dev
	2022	1.518	0.790	0.115	11.849	2.503
Y	2023	1.388	0.558	0.124	12.944	2.679
	2024	1.587	0.543	0.140	12.227	2.653
	2022	30.670	30.632	26.010	32.758	1.485
X_1	2023	30.717	30.855	27.701	32.713	1.175
	2024	30.782	31.094	27.639	32.332	1.187
	2022	0.465	0.478	0.114	1.584	0.307
X_2	2023	0.365	0.388	0.123	0.580	0.151
	2024	0.342	0.308	0.139	0.585	0.147
	2022	0.229	0.181	0.013	0.616	0.194
X_3	2023	0.159	0.133	0.001	0.403	0.127
	2024	0.129	0.099	0.002	0.467	0.120

Based on Table 1, the descriptive statistics show the characteristics of each variable during the study period from 2022 to 2024. The dependent variable (Y) has a fluctuating mean value, namely 1.518 in 2022, decreasing to 1.388 in 2023, and then increasing again to 1.587 in 2024. The median value of Y tends to be lower than its mean in each year, indicating that the distribution of Y data is positively skewed. This is reinforced by a fairly wide range of values, from 0.115 to 12.944, as well as a standard deviation ranging from 2.5 to 2.68, which is relatively large compared to the mean. This suggests that the variation in Y values across companies is quite high and that there are several companies with Y values well above the average.

For the independent variable X_1, the mean value shows a steady upward trend from 30.670 in 2022 to 30.782 in 2024. The median value, which is nearly identical to the mean, indicates a distribution that tends to be symmetrical. The relatively small standard deviation of X_1 (ranging from 1.18 to 1.49) suggests that variation among companies for this variable is not particularly large. Meanwhile, variable X_2 shows a fairly sharp decline in the mean, from 0.465 in 2022 to 0.342 in 2024. A similar decline is also observed in the median value, along with a decreasing standard deviation from 0.307 to approximately 0.147, indicating that variation among companies is becoming smaller over time. A similar pattern is observed for variable X_3, whose mean has consistently declined from 0.229 (2022) to 0.129 (2024), accompanied by a decrease in the standard deviation from 0.194 to 0.120.

Overall, these descriptive statistics indicate that the research data exhibit diverse characteristics. Variable Y has a high degree of variability, whereas variable X_1 is relatively stable. On the other hand, variables X_2 and X_3 show a significant downward trend during the observation period, which may reflect changes in economic conditions or sample characteristics. These findings reinforce the relevance of using panel data regression models, particularly fixed-effects models, which are capable of controlling for firm-specific characteristics that remain constant over time (time-invariant heterogeneity) and accommodating dynamics across time periods.

4.2. Panel Data Regression Model

Table 2. Panel Data Regression Model

Model	Variable	Estimate	P-Value	Description
Fix Effect	X_1	-0.481	0.209	Not Significant
	X_2	0.672	0.273	Not Significant
	X_3	-0.796	0.432	Not Significant
Pooled Effect	Intercept	-12.132	0.109	Not Significant
	X_1	0.381	0.113	Not Significant
	X_2	1.520	0.277	Not Significant
	X_3	7.690	0.000	Significant
Random Effect	Intercept	3.848	0.676	Not Significant
	X_1	-0.089	0.761	Not Significant
	X_2	1.036	0.071	Significant
	X_3	-0.039	0.969	Not Significant

Table 2 presents the estimation results of three panel data regression models—namely, the Fixed Effects (FE) model, the Pooled Effects (Pooled OLS) model, and the Random Effects (RE) model—to analyze the effects of the independent variables (X_1, X_2, X_3) on the dependent variable (Y). The estimation results show that in the Fixed Effects model, all independent variables—namely X_1 (coefficient -0.481; p-value 0.209), X_2 (coefficient 0.672; p-value 0.273), and X_3 (coefficient -0.796; p-value 0.432) have no statistically significant effect at the 5% or 10% significance levels. This indicates that in a model controlling for firm-specific characteristics (time-invariant heterogeneity), none of the independent variables is able to significantly explain the variation in the dependent variable Y.

In the Pooled OLS model, different results were found. Variable X_3 has a coefficient of 7.690 with a p-value of 0.000, indicating a positive and significant effect on Y at the 1% significance level. Meanwhile, variables X_1 (coefficient 0.381; p-value 0.113) and X_2 (coefficient 1.520; p-value 0.277) show an insignificant effect, although X_1 has a p-value close to the 10% significance threshold. The intercept value in this model is also not significant (p-value 0.109).

Meanwhile, in the Random Effects model, variable X_2 showed a marginally significant effect at the 10% significance level, with a positive coefficient of 1.036 and a p-value of 0.071. Variables X_1 (coefficient -0.089; p-value 0.761) and X_3 (coefficient -0.039; p-value 0.969) are not significant. The intercept is also not significant (p-value 0.676).

4.3. Selection of a Panel Data Model

Table 3. Panel Data Regression Model

Test	P-Value	Description
Chow Test	1.46E-09	The fixed-effects model is better than pooled OLS
Hausmann Test	0.002	The fixed-effects model is better than the random-effects model
Breusch-Pagan LM	0.023	The Random Effects model is better than Pooled OLS

The Chow test was conducted to choose between the Pooled OLS model and the Fixed Effects model. The results of the Chow test showed a p-value of 1.46E-09 or 0.00000000146, which is far below the 5% significance level (0.05). Thus, the null hypothesis (H_0), which states that the Pooled OLS model is better than the Fixed Effects model, is rejected. In conclusion, the Fixed Effects model is better and more appropriate to use than the Pooled OLS model. This indicates that there are significant differences in the intercepts among individuals (companies) in this study, so a model that accommodates individual effects is more suitable.

The Hausman test was conducted to choose between the Fixed Effects model and the Random Effects model. The results of the Hausman test showed a p-value of 0.002, which is less than 0.05. Therefore, the null hypothesis (H_0), which states that the Random Effects model is better, is rejected, and it is concluded that the Fixed Effects model is superior to the Random Effects model. This finding indicates a correlation between individual effects (unobserved heterogeneity) and the independent variables in the model, causing the Random Effects estimator to be inconsistent (biased), while the Fixed Effects model continues to produce consistent estimates.

The Breusch-Pagan LM test was conducted to choose between the Pooled OLS model and the Random Effects model. The results of this test showed a p-value of 0.023, which is less than 0.05. Thus, the null hypothesis (H_0), which states that the Pooled OLS model is better, is rejected, and it is concluded that the Random Effects model is better than the Pooled OLS model. This indicates that there is significant variance in the error component across individuals, making the random effects approach more appropriate than completely ignoring individual effects (pooled). Therefore, based on the three tests used, the appropriate model is the Fixed Effects Model.

4.4. Test of Classical Assumptions

Table 4. Test of Classical Assumptions

Test	P-Value	Description
Normality	2.15E-08	Not normally distributed
Autocorrelation	0.005	There is autocorrelation
Heteroskedasticity	0.029	There is Heteroskedasticity

Table 4 presents the results of tests of classical assumptions, including tests of residual normality, autocorrelation, and Heteroskedasticity for the selected panel data regression model (Fixed Effects model). These tests are important to ensure that the model used meets the criteria for the Best Linear Unbiased Estimator (BLUE) or, at the very least, to identify any violations of assumptions that need to be corrected.

The normality test of the residuals was conducted using the Shapiro-Wilk test. The test results showed a p-value of 2.15E-08, or 0.0000000215, which is far smaller than the 5% significance level (0.05). Thus, the null hypothesis (H_0), which states that the residuals are normally distributed, is rejected. In conclusion, the model residuals are not normally distributed. However, in the context of panel data regression with a sufficiently large sample size (n=63), a violation of the normality assumption is not considered a serious issue because parameter estimation remains consistent and the estimators remain unbiased, especially if the purpose of the analysis is hypothesis testing rather than interval prediction.

The autocorrelation test was conducted using the Breusch-Godfrey/Wooldridge test. The test results showed a p-value of 0.005, which is less than 0.05. Therefore, the null hypothesis (H_0), which states that there is no autocorrelation, is rejected. In conclusion, there is an autocorrelation issue in the model. Autocorrelation in panel data can cause standard errors to be underestimated, rendering significance tests invalid (tending to be overly optimistic). To address this issue, researchers can use clustered standard errors at the individual (firm) or time (year) level, as well as consider adding lags to the dependent variable or using a dynamic model.

The Heteroskedasticity test was conducted using the Breusch-Pagan test. The test results showed a p-value of 0.029, which is less than 0.05. Thus, the null hypothesis (H_0), which states that the residual variance is constant (homoscedasticity), is rejected. In conclusion, there is a problem of Heteroskedasticity in the model, which means that the residual variance is not constant across individuals or over time. Heteroskedasticity can cause standard errors to be inefficient and significance tests to be unreliable.

4.5. Robust Panel Data Regression Model with Standard Error

Table 5. Robust Panel Data Regression Model with Standard Error

Model	Variable	Estimate	P-Value	Description
	X_1	-0.481	0.038	Significant
Fix Effect	X_2	0.672	0.018	Significant
	X_3	-0.796	0.092	Significant

Table 5 presents the results of the fixed-effects model estimation after correcting for Heteroskedasticity and autocorrelation using cluster-robust standard errors (clustering by time). As noted in Table 4, the initial model violated the assumptions of Heteroskedasticity (p=0.029) and autocorrelation (p=0.005). Therefore, correcting the standard errors is crucial to ensure that conclusions regarding the significance of independent variables are valid and reliable.

Based on the results in Table 5, after adjusting for robust standard errors, all independent variables were found to have a significant effect on the dependent variable (Y), albeit at varying levels of significance.

Variable X_1 has a coefficient of -0.481 with a p-value of 0.038. Since the p-value is less than 0.05, X_1 has a negative and significant effect on Y at the 5% significance level. This means that a one-unit increase in X_1 will decrease the value of Y by 0.481 units, assuming all other variables remain constant (ceteris paribus).

Variable X_2 has a coefficient of 0.672 with a p-value of 0.018, which is also less than 0.05. Thus, X_2 has a positive and significant effect on Y at the 5% significance level. This means that a one-unit increase in X_2 will increase the value of Y by 0.672 units.

Variable X_3 has a coefficient of -0.796 with a p-value of 0.092. Since this p-value falls between 0.05 and 0.10, X_3 has a negative and marginally significant effect at the 10% significance level. This means that, at a 90% confidence level, a one-unit increase in X_3 will decrease the value of Y by 0.796 units.

Based on the analysis in Table 5, which uses a fixed-effects model with robust standard errors, the R-squared value obtained is 0.176 (17.6%). This value indicates that, collectively, the independent variables (X_1, X_2, and X_3) can only explain approximately 17.6% of the variation in the dependent variable (Y), while the remaining 82.4% is explained by other factors outside the model. Meanwhile, the F-statistic for this model is 2.778 with a p-value of 0.0538. At a 10% significance level (α = 0.10), the p-value of 0.0538 is still below 0.10, so it can be concluded that there is a marginally significant simultaneous effect of X_1, X_2, and X_3 on Y. Thus, the results in Table 6 show a comparison of the values before and after the Standard FEM and Robust FEM analyses.

Table 6. Comparison of Results from Standard FEM and Robust FEM

Variable	FEM Standard (P-Value)	FEM Robust (P-Value)	Description
X_1	0.209 (Not Significant)	0.038 (Significant)	Increasing
X_2	0.273 (Not Significant)	0.018 (Significant)	Increasing
X_3	0.432 (Not Significant)	0.092 (Significant)	Increasing

Table 6 presents a comparison of the estimation results between the standard Fixed Effects Model (FEM) and the FEM model adjusted using cluster-robust standard errors (clustering by time). In the standard FEM, all independent variables firm size (X_1), leverage (X_2), and profitability (X_3) exhibit p-values above 0.05, indicating they are not statistically significant. However, after correcting for violations of the assumptions of heteroscedasticity and autocorrelation using robust methods, there is a highly significant increase in the significance of all three variables. The p-value for X_1 dropped sharply from 0.209 to 0.038 (significant at α=5%), X_2 from 0.273 to 0.018 (significant at α=5%), and X_3 from 0.432 to 0.092 (marginally significant at α=10%). These changes indicate that the standard errors in the initial model were biased (tending to be too large) due to the presence of heteroscedasticity and autocorrelation; thus, without correction, conclusions regarding the significance of the variables would be inaccurate. Thus, the robust FEM results are more reliable and serve as the primary basis for the research conclusion that firm size has a significant negative effect, leverage has a significant positive effect, and profitability has a marginally significant negative effect on firm value in the Indonesian mining sector for the 2022–2024 period.

5. **Conclusion**

This study aims to analyze the effects of firm size, leverage (DER), and profitability (ROA) on firm value (PBV) among mining companies listed on the Indonesia Stock Exchange during the 2022–2024 period. Based on the Chow and Hausman tests, the best model selected is the Fixed Effects Model (FEM). After correcting for violations of the assumptions of Heteroskedasticity and autocorrelation using robust standard errors, the results show that simultaneously, all three independent variables have a significant effect on firm value. Partially, firm size (X_1) has a negative and significant effect, leverage (X_2) has a positive and significant effect, and profitability (X_3) has a negative and marginally significant effect on firm value. An R-squared value of 17.6% indicates that the three variables can only explain a small portion of the variation in firm value, so further exploration of other factors outside the model is still needed. Thus, the hypotheses proposed in this study are accepted, and these findings imply that investors and company management need to comprehensively consider the factors of firm size, debt structure, and profitability in making investment decisions and formulating strategies to enhance firm value in the Indonesian mining sector.

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