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Comparison of CEM, FEM and REM Models, Case Study of Return nn Assets

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Abstract

This research compares three panel data regression models Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM) to analyze Return on Assets (ROA) in state-owned banks in Indonesia in the period 2022 to 2024. ROA is used to measure bank efficiency in utilizing assets to generate profits and operational profitability. The panel data approach combines cross-section and time series dimensions, which allows dynamic analysis between individuals and periods. The results of the analysis show that for the Chow, Hausman, and Lagrange Multiplier tests, the CEM model is more appropriate to use compared to the FEM and REM models because there are no significant differences that support the use of other models. BOPO (x_3) has a significant effect on ROA with a p-value of 0.000, while LDR/FDR (x_1) and NIM (x_2) do not have a significant effect. The CEM model can explain 97.60% of the variation in ROA, although several independent variables are not significant.

Keywords: *Common Effect Model, Fixed Effect Model, Random Effect Model, Return On Assets*

Introduction

Ordinary Least Squares (OLS) is a method that is widely used to test the influence of predictor variables on response variables. However, OLS is basically more suitable for cross-section data, that is, data collected at one point in time. This is different from panel data, because panel data combines cross-section and time series dimensions simultaneously. The combination of these two dimensions makes the data structure more complex, so that ordinary OLS models cannot be directly applied. Panel data has characteristics such as fixed differences between units, changes in conditions over time, and the possibility of correlation within one unit throughout the observation period. Therefore, panel data analysis requires special methods that can capture these dynamics.

Several previous studies have also used panel data methods in various cases. For example, research by (Nuralyatussa'ada et al., 2024) applies a panel data model to analyze inflation and the Human Development Index. Then,, used panel data to examine the factors that influence poverty in South Sulawesi Province(Anisa et al., 2012). Other research by. also applied the panel data method in the case of the Human Development Index(Sutikno et al., 2017). Likewise, research by (Hutagalung & Darnius, 2022) is the same as research from (Nuralyatussa'ada et al., 2024) and (Sutikno et al., 2017) which uses a panel data approach to analyze community welfare indicators. In this research, we try to compare the CEM, FEM and REM models in the case of ROA at state-owned banks in Indonesia in the period 2022 to 2024.

In this research, a panel data approach is used to compare three main models, namely the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM) in the case of Return on Assets (ROA) in Indonesian state-owned banks for the period 2022 to 2024. ROA (Return on Assets) in the banking case can describe how efficient the Bank is in utilizing all its assets to generate profits. In addition, ROA is considered an indicator that reflects the operational profitability and effectiveness of bank asset management. By using ROA, research can provide a more objective picture of the financial performance of state-owned banks in that period.

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Method

Panel Data Regression Model

Common Effect Model (CEM)

The Common Effect Model (CEM) is a panel data analysis method that assumes that the intercept and slope values in the regression equation are the same for all individual units and all time periods. so the model can be estimated using the Ordinary Least Squares (OLS) method without adding individual effects or time effects (Rahayu et al., 2023). The equations for the CEM model

$$Y_{it} = \beta_0 + \beta_1 x_{1it} + \cdots + +\beta_n x_{nit}; i = 1,2, \dots, P; t = 1,2, \dots, T \quad (1)$$

Where $\boldsymbol{\beta} = [\boldsymbol{\beta_1} \quad \boldsymbol{\beta_2} \quad \dots \quad \boldsymbol{\beta_i} \quad \cdots \quad \boldsymbol{\beta_n}]^T$,

$\boldsymbol{x}$ independent variable for the to - i cross section unit of the to - t period is vector size $(n \times p)$

$$\boldsymbol{x} = \begin{bmatrix} \boldsymbol{x_{i11}} & \boldsymbol{x_{i12}} & \dots & \boldsymbol{x_{i1j}} & \cdots & \boldsymbol{x_{i1p}} \\ \boldsymbol{x_{i21}} & \boldsymbol{x_{i22}} & \dots & \boldsymbol{x_{i2j}} & \dots & \boldsymbol{x_{i2p}} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \boldsymbol{x_{ij1}} & \boldsymbol{x_{ij2}} & \dots & \boldsymbol{x_{ijj}} & \dots & \boldsymbol{x_{ijp}} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ \boldsymbol{x_{in1}} & \boldsymbol{x_{in2}} & \dots & \boldsymbol{x_{inj}} & \dots & \boldsymbol{x_{inp}} \end{bmatrix}$$

$\boldsymbol{Y}$ is the dependent variable (predicted value) of the i-th cross section unit for the to-t period with size $\boldsymbol{Y} = [\boldsymbol{y_1} \quad \boldsymbol{y_2} \quad \dots \quad \boldsymbol{y_j} \quad \cdots \quad \boldsymbol{y_n}]^T$

In the parameter estimation process for the CEM model, four approaches can be used. First, Ordinary Least Squares (OLS) is applied when the data satisfy the assumption of homoskedasticity and there is no correlation across cross-sectional units. Second, Weighted Least Squares (WLS) is used when heteroskedasticity is present but there is still no cross-sectional correlation. Third, Seemingly Uncorrelated Regression (SUR) is employed when the data exhibit both heteroskedasticity and cross-sectional correlation. Finally, Feasible Generalized Least Squares (FGLS) with an autoregressive (AR) component is chosen when the residuals are heteroskedastic and serial correlation occurs over time.

Fixed Effect Model (FEM)

The Fixed Effect Model (FEM) is used to capture unobserved heterogeneity individual characteristics that cannot be directly measured but remain constant over time. In this model, it is assumed that each individual has a different intercept, while the slope coefficients of the independent variables remain the same across all individuals. By doing so, FEM effectively controls for potential bias arising from unobserved variables that are correlated with the independent variables, thereby producing more consistent and reliable parameter estimates. (Srihardianti et al., 2016).

$$Y_{it} = \beta_0 + \beta_1 x_{1it} + \cdots + +\beta_n x_{nit} + \alpha_i + \mu_{it}; i = 1,2, \dots, P; t = 1,2, \dots, T \quad (2)$$

Where $\alpha_i = \grave{Z_i}\alpha_i$ represents all observable individual effects and captures the conditional mean differences across observational units. The parameter α_i is treated as an unknown constant that must be estimated. The component $\grave{Z_i}$is considered unobserved and is allowed to be correlated with the independent variables. Parameter estimation in the fixed effects model can be performed using three approaches, depending on the assumptions regarding the structure of the residual variance–covariance matrix. These estimation methods are essentially consistent with the techniques used in the CEM model.

Random Effect Model (REM)

In the random effects model, differences in characteristics across individuals and over time are not incorporated as separate intercepts as in the fixed effects model. Instead, these differences are included in the error component. Since the sources of heterogeneity arise from two factors—individual effects that remain constant over time and time effects experienced by all individuals—the total error must be separated into two parts: the individual-specific error and the usual random error. By separating these error components, the random effects model is able to capture variation that stems from both cross-sectional differences and time-series fluctuations. This results in a more comprehensive error structure compared to the standard regression model. The random effects model (REM) can be written as: (Madany & Rais, 2022)

$$Y_{it} = \beta_0 + \beta_1 x_{1it} + \cdots + +\beta_n x_{nit} + \alpha_{it} + \mu_{it}; i = 1,2, \ldots, P; t = 1,2, \ldots, T \quad (3)$$

Goodness Of Fit Test

Chow Test

Chow test is used to select a model between the Common Effect Model and the Fixed Effect Model (Indrasetianingsih & Wasik, 2020). The Chow test equation is as follows

Hypothesis :

$H_0 = \beta_i = 0$ Common Effect Model

$H_1 = \beta_i \neq 0$ Fixed Effect Model

$$F_{Hitung} = \frac{(RSS_1 - RSS_2)/(N-1)}{RSS_2/(NT-N-P)} \quad (4)$$

N = Number of observations

T = Number of Time Periods

P = Number of predictors

RSS_1= residual sum of squares from the Common Effect Model estimation results

RSS_2= residual sum of squares from the Fixed Effect Model estimation results

Hausman Test

The Hausman test is used to select a model between the Fixed Effect Model and the Random Effect Model (Dewi et al., 2023) The Chow test equation is as follows

Hypothesis :

$H_0 = \beta_i = 0$ Random Effect Model

$H_1 = \beta_i \neq 0$ Fixed Effect Model

$$H = \left(\hat{\beta}_{FEM} - \hat{\beta}_{REM}\right)^T \left[Var\left(\hat{\beta}_{FEM}\right) - Var\left(\hat{\beta}_{REM}\right)\right]^{-1} \left(\hat{\beta}_{FEM} - \hat{\beta}_{REM}\right) \quad (5)$$

$\hat{\beta}_{FEM}$ = coefficient estimator of the Fixed Effects model

$\hat{\beta}_{REM}$ = coefficient estimator of the Random Effects model

Langrange Multiplier Test.

Langrange Multiplier Test. Used to select a model between the Common Effect Model and the Random Effect Model (Elisa et al., 2025) The Langrange Multiplier test equation is as follows

Hypothesis:

$H_0 = \beta_i = 0$ Common Effect Model

$H_1 = \beta_i \neq 0$ Random Effect Model

$$LM = \frac{NT}{2(T-1)}\left(\frac{\sum_{i=1}^{n}\bar{e}_i^2}{\hat{\sigma}^2}\right)^2 \quad (6)$$

Where $\hat{\sigma}^2$ is variance of the residuals from the CEM, $\hat{e}_i^2$ is average residual for each cross-section unit.

Results and Discussion

Descriptive Analysis

Descriptive analysis is used to describe the structure of the data in the study. Comparison of CEM, FEM, and REM Models: A Case Study of Return on Assets of Indonesian State Owned Banks

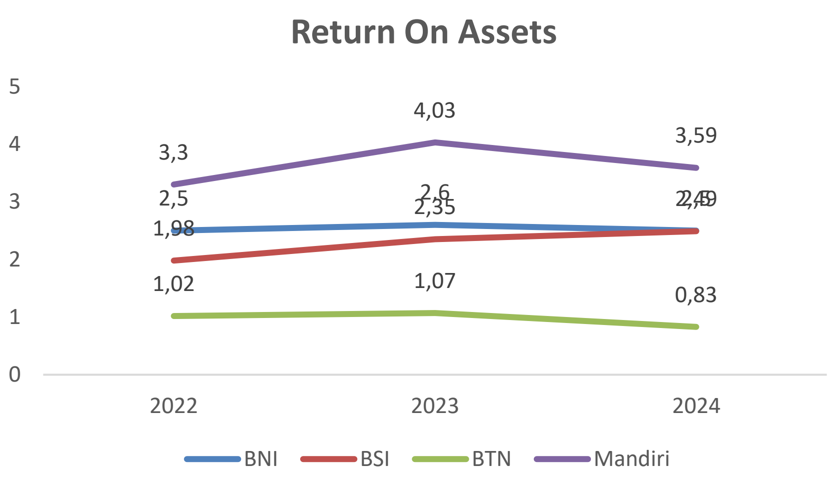

Figure 1. Return On Assets

Based on Figure 1, the Return on Assets (ROA) of the four major banks in Indonesia shows varying patterns from 2022 to 2024. BNI maintains a relatively stable ROA level, around 2.5 percent in 2022, slightly increasing to 2.6 percent in 2023, and returning to 2.5 percent in 2024. This pattern reflects the consistency of BNI's profitability performance over the past three years. In contrast to BNI, BSI exhibits a strong upward trend in ROA, rising from 1.98 percent in 2022 to 2.35 percent in 2023, and reaching 2.49 percent in 2024. This continuous improvement indicates enhanced operational efficiency and strengthened profitability of the country's largest Islamic bank.

Figure 1 also shows that BTN experienced more significant fluctuations in its ROA. After recording 1.02 percent in 2022, BTN's ROA increased slightly to 1.07 percent in 2023, but then declined sharply to 0.83 percent in 2024. This decrease indicates pressure on asset performance that requires attention. On the other hand, Bank Mandiri consistently recorded the highest ROA among the four banks, rising from 3.30 percent in 2022 to 4.03 percent in 2023, before slightly correcting to 3.59 percent in 2024. Nevertheless, Mandiri remains the bank with the strongest profitability throughout the observation period. Overall, the data show that Mandiri leads in ROA performance, BSI experiences solid growth, BNI remains stable, and BTN faces a decline in profitability in the final year.

Goodness Of Fit Test

In selecting the best model among the Common Effect Model (CEM), Fixed Effect Model (FEM), and Random Effect Model (REM), several tests were conducted, including the Chow Test, the Hausman Test, and the Lagrange Multiplier Test. The results are presented as follows.

Table 1 Goodnes Of fit

Test Name	P-Value
Chow Test	0.9808
Hausman Test	0.9874
Lagrange Multiplier Test	1.000

The Chow Test is used to examine whether there are significant differences between the models involving BNI, BSI, BTN, and Mandiri. Based on Table 1, the results indicate that there are no significant differences in the coefficients for BNI, BTN, BSI, and Mandiri. The p-value > $\alpha_{5\%}$ which indicates that we fail to reject the null hypothesis. This means that the differences among banks in this model are not significant. Therefore, the banks can be pooled into a single model without reducing the quality of the estimation.. Based on Table 1, it is also evident that the CEM model performs better than the FEM model, and thus the next step is to conduct the Lagrange Multiplier Test, which compares the CEM and REM models. According to Table 1, the p-value > $\alpha_{5\%}$, indicating that the Random Effects model is not superior to the CEM model. Therefore, the CEM model is more appropriate for this dataset, as there is no significant evidence showing that random effects provide a better contribution.

Common Effect Model

In this analysis, a regression using the Common Effect Model (CEM) was conducted to understand the relationship between the dependent variable ROA (Y) and several independent variables: LDR/FDR LDR/FDR (x_1), NIM (x_2) and BOPO (x_3). T able 1 below presents the estimation results of the CEM model, including the coefficient values, standard errors, t-statistics, and p-values used to test the significance of the regression coefficients.

Table 2 Common Effect Model

```
      Source |       SS       df       MS              Number of obs =      12
-------------+------------------------------           F(  3,     8) =  108.56
       Model |  10.9743368     3  3.65811228           Prob > F      =  0.0000
    Residual |  .269563152     8  .033695394           R-squared     =  0.9760
-------------+------------------------------           Adj R-squared =  0.9670
       Total |     11.2439    11  1.02217273           Root MSE      =  .18356

------------------------------------------------------------------------------
           Y |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
          X1 |   .0092105   .0112183     0.82   0.435     -.016659    .0350801
          X2 |   .0576406   .0919336     0.63   0.548    -.1543587    .2696398
          X3 |  -.0880885   .0058245   -15.12   0.000    -.1015197   -.0746572
       _cons |   7.551297   1.475219     5.12   0.001     4.149436    10.95316
```

Based on the results presented in Table 1, the regression model shows that LDR/FDR (x_1) and NIM (x_2) do not have a significant effect on ROA. The coefficient of LDR/FDR LDR/FDR (x_1) is 0.0092105, but p-value 0.435> $\alpha_{5\%}$, indicating that LDR/FDR (x_1) does not provide a significant contribution in predicting ROA. Similarly, although the coefficient of NIM (x_2), The P-Value P-Value 0.548 > 0. $\alpha_{5\%}$, yang juga menandakan bahwa NIM (x_2) also indicates that NIM (x_2) does not significantly affect ROA. Conversely, BOPO (x_3) has a coefficient of –0.0880885 with a p-value < α (5%), indicating that BOPO (x_3) has a highly significant effect on ROA. The negative coefficient of BOPO (x_3) shows that an increase in BOPO will reduce the ROA value. This significant negative influence reinforces the importance of BOPO (x_3) in the model.

This model has an R-squared value of 0.9760, which means that 97.60% of the variation in ROA can be explained by the CEM model. The very high R-squared value indicates that the model is able to explain nearly all variations in the data, even though some independent variables are not significant. Therefore, although LDR/FDR and NIM do not provide significant contributions in this model, BOPO (x_3) remains the key factor that should be considered in future analyses due to its clear influence on bank performance.

Conclusion

The results of the CEM model show that BOPO (x_3) is a significant variable influencing ROA, while LDR/FDR (x_1) and NIM (x_2) do not have a significant effect. The model has an R-squared value of 0.9760, which means that 97.60% of the variation in ROA can be explained by this model. Although some variables are not significant, the model as a whole is still able to explain most of the variation in the data. Therefore, even though not all independent variables have a significant effect, BOPO (x_3) remains the key factor that should be considered in this model. In this study, only cross-sectional and time series data were combined, leaving certain aspects unobserved, such as spatial dimensions. Therefore, future research is expected to incorporate the development of cross-sectional data, time series data, and spatial data.

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References

Anisa, Ilyas, N., & Hadijah. (2012). Analisis Data Panel Model Efek Acak pada Data Kemiskinan di Provinsi Sulawesi Selatan. *Jurnal Matematika, Statistika Dan Komputasi*, *8*(2), 110–130.

Dewi, A., Chairunnisa, A., & Fauzan, A. (2023). Implementation of Panel Data Regression in the Analysis of Factors Affecting Poverty Levels in Bengkulu Province in 2017-2020. *EKSAKTA : Journal of Sciences and Data Analysis*, *4*(1), 40–45. https://doi.org/10.20885/EKSAKTA.vol

Elisa, N., Aidid, M. K., & Meliyana, S. M. (2025). Regression Analysis of Panel Data on Gross Enrolment Rate (GER) At Junior High School and Equivalent Education Levels in South Sulawesi Province in 2018-2022. *Quantitative Economics and Management Studies (QEMS)*, *6*(1), 99–107.

Hutagalung, I. P., & Darnius, O. (2022). Analisis Regresi Data Panel Dengan Pendekatan Common Effect Model (CEM), Fixed Effect Model (FEM) dan Random Effect Model (REM). *FARABI Jurnal Matematika Dan Pendidikan Matematika*, *5*(2), 217–226.

Indrasetianingsih, A., & Wasik, T. K. (2020). Model regresi data panel untuk mengetahui faktor yang mempengaruhi tingkat kemiskinan di pulau madura. *JURNAL GAUSSIAN*, *9*(2018), 355–363.

Madany, N., & Rais, Z. (2022). Regresi Data Panel dan Aplikasinya dalam Kinerja Keuangan terhadap Pertumbuhan Laba Perusahaan Idx Lq45 Bursa Efek Indonesia. *VARIANSI: Journal of Statistics and Its Application on Teaching and Research*, *4*(2), 79–94. https://doi.org/10.35580/variansiunm28

Nuralyatussa'ada, Herdiani, E. T., & Sirajang, N. (2024). Analisis Regresi Data Panel Dengan Model Efek Umum , Model Efek Tetap Dan Model Efek Acak (Studi Kasus : Inflasi Dan Indeks Pembangunan Manusia). *ESTIMASI: Journal of Statistics and Its Application*, *5*(2), 282–295.

Rahayu, K., Aidid, M. K., & Rais, Z. (2023). Analisis Regresi Data Panel Pada Angka Partisipasi Murni (APM) Jenjang Pendidikan Smp Sederajat Di Provinsi Jawa Barat Pada Tahun 2018-2021. *VARIANSI: Journal of Statistics and Its Application on Teaching and Research*, *5*(2), 64–73. https://doi.org/10.35580/variansiunm113

Srihardianti, M., Mustafid, & Prahutama, A. (2016). Metode regresi data panel untuk peramalan konsumsi energi di indonesia. *JURNAL GAUSSIAN*, *5*(3), 475–485.

Sutikno, B., Faruk, A., & Dwipurwani, O. (2017). Penerapan Regresi Data Panel Komponen Satu Arah untuk Menentukan Faktor-Faktor yang Mempengaruhi Indeks Pembangunan Manusia. *Jurnal Matematika Integratif*, *13*(1), 1–10.