Application of Equation Model with Two-Stage Least Squares Approach on Factors Affecting the Operational Efficiency Ratio of Banking Performance in Indonesia

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Abstract: In regression models, there are variables that are interrelated, requiring a method that can accommodate these variables, namely the simultaneous equation method. This study aims to determine the factors influencing Sustainability and the Operational Efficiency Ratio of Banking Performance in Indonesia and to model the simultaneous equations for the factors affecting Sustainability and the Operational Efficiency Ratio of Banking Performance in Indonesia using the two-stage least squares approach. The data in this study is secondary data obtained from the website of the Financial Services Authority. The results of the study show that in the simultaneous equation model using the two-stage least squares approach, the variable that significantly affects Sustainability is Digital Innovation. Meanwhile, the variables that significantly affect the Operational Efficiency Ratio of Banking Performance are Predicted Sustainability and Company Size. Based on the prediction values using the Sustainability and Operational Efficiency Ratio equations, the obtained MAPE value does not exceed 50%, indicating that the prediction results using the Sustainability and Operational Efficiency Ratio equations show accurate predictions.

Keywords: Sustainability, Digital Innovation, Intellectual Capital, Operational Efficiency Ratio (OER).

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1. Introduction

A statistical model used to determine causal relationships between one variable and another is called regression analysis. The most commonly encountered regression model in statistics is usually a single equation model. However, there may also be interdependence, where variables are interconnected, resulting in a bidirectional relationship in some models. In econometrics, such models are known as simultaneous equation models [30]. A simultaneous equation model explains endogenous variables together. Therefore, this study employed the commonly used two-stage least squares (2SLS) method to address the endogeneity problem. The model involves two stages of regressions to provide consistent coefficient estimates for variables with endogeneity [38].

In simultaneous equations, an endogenous variable will become an exogenous variable in another equation, making it likely to be highly correlated with the error term (endogeneity occurs). The advantage of using the 2SLS estimation model is that it reduces potential bias caused by the endogeneity of the key variable [38]. Several methods that can be used include the Reduced-Form Equations, Two-Stage Least Squares, Indirect Least Squares, and Three-Stage Least Squares. In economic modelling, the use of the Two-Stage Least Squares method is appropriate because this estimation method can be applied in both identified and over-identified conditions [31].

In constructing an economic model, meticulous attention is required in selecting interrelated variables. According to the characteristics of each economic variable, which act as independent variables, these variables can also become dependent variables in some contexts [31]. For example, the relationship between Sustainability and Financial Performance. It is stated that Sustainability, Digital Innovation, Intellectual Capital, and Organizational Ambidexterity can influence the financial performance of banks [35]; [33]; [24]; [2]; [11,12]; [39]; [7]; [14]; [19]; [34]; [4]; [8]; [22]; [15]; [5]; [9]; [36].

However, on the other hand, Sustainability is also influenced by Digital Innovation, Intellectual Capital, and Organizational Ambidexterity [1]; [35]; [17]; [29]; [4]; [27]; [20]; [21]; [13] Ali et al. (2021); [18]; [37]; [40]; [23]. Financial Performance can also be influenced by Company Size and Leverage [32]; [26]; [6]; [25]; [28]; [10]. In regression models, there is a method that can accommodate interrelated variables, namely the 2SLS or simultaneous equation model. The 2SLS method was introduced by Theil and Basmann [31].

2 Research Method

This study was conducted on all banks in Indonesia using secondary data in the form of Annual Financial Statements and Sustainability Reports. The variables used in the study include Digital Innovation, Intellectual Capital, Organizational Ambidexterity, Sustainability, Operational Efficiency Ratio, Company Size, and Leverage.

2.1 Variables

Dependent variables

Operation Efficiency Ratio (OER) [41]

$$\text{OER} = \frac{\text{Operating costs}}{\text{Operating Income}} \quad (1)$$

Bank Sustainability (BS) [42]

$$\frac{\text{Bank's obligation fulfillment score towards ESGE}}{\text{Max Score}} \quad (2)$$

Independent variables

Digital Innovation (DI) [43]

$$\frac{\text{score of digital facilities owned by the Bank}}{\text{Max Score}} \quad (3)$$

IntellectualCapital (IC)

[Pulic Model (1998)]

$$VAIC™ = VACA + VAHU + STVA \quad (4)$$

Organizational Ambidexterity (OA)[39]

$$\frac{\text{Total R\&D Expenditure in new product}}{\text{Total R\&D Investment of a firm}} \quad (5)$$

Control variables

Leverage (DER) [3]

$$\text{DER} = \text{Total Debt / Total Shareholders' Equity} \quad (6)$$

Firm Size (LnA) [32]

$$\text{Size} = \text{Ln Total Asset} \quad (7)$$

The data for this study consists of 92 secondary data points obtained from the OJK Indonesia website for the years 2017-2022. The sampling technique used is sampling. The analysis method employed is the Simultaneous Equation Model with the Two-Stage Least Squares approach. Data analysis is performed using EViews 10 software. The steps of analysis in this study are as follows:

a. Determine the equation model,
b. Test 2SLS requirements with the Order Condition,
c. Estimate parameters using the Two-Stage Least Squares approach,
d. Predict values using Equation Models 1 and 2,
e. Conclusions.

3 Results and Discussion

3.1 Determining the Equation Model

In the context of the Two-Stage Least Squares (2SLS) model, the variables Digital Innovation (DI), Intellectual Capital (IC), Organizational Ambidexterity (AO), Leverage (DER), and Company Size (LnAT) are used to explore the relationships between Sustainability (SUS) and Operational Efficiency Ratio (OER). Below are the two simultaneous 2SLS equations based on the established steps:

$SUS = \beta 0 + \beta 1\, DI + \beta 2\, IC + \beta 3\, AO + u$ (1)
$OER = \gamma 0 + \gamma 1\, Predict\, SUS + \gamma 2\, LnAT + \gamma 3\, LEV + v$ ..... .(2)

Whereas:
Y_1 : Sustainability (SUS)
Y_2 : Efficiency Ratio (OER)
X_1 : Digital Innovation (DI)
X_2 : Intellectual Capital (IC)
X_3 : Ambidexterity Organization (AO)
X_4 : Company Size (LnAT)
X_5 : Leverage (DER)
β and γ : Coefficients to be estimated.
u and v : Error terms representing unobserved variables that can influence SUS and OER.
In the implementation of 2SLS, instrumental variables are used to address potential endogeneity between SUS and OER in both equations.

3.2 2SLS Requirement Test with Order Condition

To analyze the model identification condition, the identification formula K−kK - kK−k or >m−1> m - 1>m−1 is used. The identification criteria for an equation model are as follows:

- If K−k>m−1K - k > m - 1K−k>m−1, the model is considered **overidentified** (TSLS).
- If K−k=m−1K - k = m - 1K−k=m−1, the model is considered **just/exactly identified** (ILS).
- If K−k<m−1K - k < m - 1K−k<m−1, the model is considered **underidentified**.

$SUS = \beta 0 + \beta 1\, DI + \beta 2\, IC + \beta 3\, AO + u$(1)
$OER = \gamma 0 + \gamma 1\, Predict\, SUS + \gamma 2\, LnAT + \gamma 3\, LEV + v$ ..... (2)

For the identification condition K−k>m−1K - k > m - 1K−k>m−1; with m=2m = 2m=2, K=8K = 8K=8, and k=2k = 2k=2, the model is considered **overidentified**.

Based on the results presented in the table above, it indicates that both Equation Models 1 and 2 are overidentified, meaning that both models are correctly identified and thus the Two-Stage Least Squares approach can be used.

3.3 Parameter Estimation Using the Two-Stage Least Squares Approach

3.3.1 Estimation of Parameters for the SUS Equation Model

The results of the parameter estimation using the Two-Stage Least Squares approach for the SUS equation model are presented in **Table 2**.

Table 2 Estimated Parameter Values for the SUS Equation Model

Variable	Coefficient	t-statistics	p-value
C	0.256419	7.797650	0.0000
DI	0.557269	11.92962	0.0000
IC	-1.31E-05	-0.348387	0.7277
AO	2.21E-05	0.297779	0.7660

Based on Table 2, it is known that the variable significantly affecting Sustainability is Digital Innovation.

3.3.2 Parameter Estimation for the BOPO Equation Model

The results of the parameter estimation using the Two-Stage Least Squares approach for the Efficiency Ratio equation model (2) are presented in **Table 3**.

Table 3 Estimated Parameter Values for the Efficiency Ratio Equation Model

Variable	Coefficient	t-statistics	p-value
C	128.9311	8.779769	0.0000
Predict SUS	37.57317	2.453370	0.0145
LnAT	-6.503490	-4.346204	0.0000
DER	0.002415	0.708605	0.4789

Based on Table 3, it is known that the variables significantly affecting the Efficiency Ratio are Predicted Sustainability and Company Size.

3.4 Predicting Values Using Equation Models 1 and 2

To determine the prediction results, the accuracy can be measured by validating each model using various indicators. One such indicator is the Mean Absolute Percentage Error (MAPE). The range of values indicating the significance of the percentage error in MAPE is as follows: the MAPE value is considered acceptable if it does not exceed 50%. If the MAPE value is above 50%, the prediction model is deemed unusable. This means that the smaller the percentage error in MAPE, the more accurate the prediction. The formula to calculate MAPE is provided below [16]:

$$MAPE = \sum_{t=1}^{n} \frac{Yi - \hat{Y}i}{\hat{Y}i}\, x\, 100\% \quad (3)$$

3.4.1 Predicted Values Using Equation Model 1

The simultaneous equation model with the two-stage least squares approach for Sustainability is represented by the following equation:

SUB = 0.256419 + 0.557269 DI – 0.0000131 IC + 0.0000221 AO …….……. (4)

Based on the sustainability equation model, the coefficients for each variable are already known, so the predicted value of sustainability can be calculated by substituting the values of the independent variables into the model. The prediction results for the sustainability equation model are presented in **Table 4**

Table 4 Actual Data and Prediction Results of the Sustainability Model for the Years 2017-2022

Year	Model Sustainability		
	Actual Data (At)	Prediction Results (Ft)	(At – Ft)/At
2017	46.65	52.93	-0.13
2018	51.43	56.96	-0.11
2019	58.99	58.37	0.01
2020	61.49	60.60	0.01
2021	63.84	61.99	0.03
2022	69.95	62.67	0.10
MAPE Values			-0.01

Based on the prediction results for the Sustainability model, the MAPE value for the Sustainability equation model is 1%. This means that the MAPE value does not exceed 50%. Thus, it can be concluded that the prediction results of the Sustainability model are accurate.

3.4.2 Predicted Values Using Equation Model 2
The equation model with the two-stage least squares approach for the Operational Efficiency Ratio is represented by the following equation:

OER = 128.9311 + 37.57317 Predict Sus – 6.503490 LnAT + 0.002415 DER ……..(5)

Based on the Operational Efficiency Ratio equation model, the coefficients for each variable are already known. Therefore, the predicted value of the Operational Efficiency Ratio can be calculated by substituting the values of the independent variables into the model. The prediction results for the Operational Efficiency Ratio equation model are presented in **Table 5**.

Table 5 Actual Data and Prediction Results of the Efficiency Ratio Model for the Years 2017-2022

Year	Model Efficiency Ratio		
	Actual Data (At)	Prediction Results (Ft)	(At – Ft)/At
2017	7.94	8.09	-0.02
2018	8.02	8.18	-0.02
2019	8.12	8.23	-0.01
2020	8.39	8.24	0.02
2021	8.84	8.19	0.07
2022	7.89	8.15	0.03
MAPE Values			0.10

Based on the prediction results for the Operational Efficiency Ratio model, the MAPE value for the Operational Efficiency Ratio equation model is 10%. This means that the MAPE value does not exceed 50%. Thus, it can be concluded that the prediction results of the Operational Efficiency Ratio model are accurate.

4 Conclusion

The simultaneous equation model with the two-stage least squares approach for Sustainability is represented by Equation 3. Based on this Sustainability equation, it can be said that the only factor influencing Sustainability is Digital Innovation, while Intellectual Capital and Organizational Ambidexterity do not significantly affect Sustainability.

Meanwhile, the simultaneous equation model with the two-stage least squares approach for the Operational Efficiency Ratio is represented by Equation 4. Based on this Operational Efficiency Ratio equation, it can be said that the factors influencing the Operational Efficiency Ratio are Predicted Sustainability and Company Size, while Leverage does not significantly affect the Operational Efficiency Ratio.

The prediction results for the inflation and Operational Efficiency Ratio equations, using the MAPE indicator, show MAPE values of less than 50%. Thus, it can be concluded that the predictions for the inflation equation and Operational Efficiency Ratio are accurate.

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