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Technical Efficiency Of Rural Banks In East Java: A Two-Stage Data Envelopment Analysis Approach

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Abstract

This study aims to measure the technical efficiency of Rural Banks (BPR) in East Java Province during the period 2021–2023 and to identify the determinants of efficiency using a two-stage approach. The research employs a quantitative method with secondary data obtained from financial reports published by the Financial Services Authority (OJK). In the first stage, efficiency scores are calculated using an input-oriented Data Envelopment Analysis (DEA) under the Variable Returns to Scale (VRS) assumption. In the second stage, a Tobit regression model is applied to examine the influence of internal bank factors on efficiency scores. The findings reveal that only 6 out of 20 BPRs consistently achieved full efficiency during the observation period, while the remaining banks exhibited varying levels of inefficiency. The second-stage analysis indicates that Capital Adequacy Ratio (KPM) and Return on Assets (ROA) significantly influence efficiency, whereas Non-Performing Loans (NPL) and bank size do not show a significant effect. These results suggest that internal financial performance plays a crucial role in improving bank efficiency. This study contributes to the literature by providing empirical evidence on the efficiency dynamics of rural banking institutions in developing regions and offers policy implications for improving financial performance and operational efficiency in the rural banking sector.

Keywords: technical efficiency, rural banks, DEA, Tobit regression, financial performance

JEL Classification: G21, C14, C24

INTRODUCTION

The banking sector plays a fundamental role in economic development through its intermediation function, particularly in developing countries such as Indonesia. Rural banking institutions, known as Bank Perkreditan Rakyat (BPR), are essential in promoting financial inclusion by providing accessible financial services to micro, small, and medium enterprises (MSMEs) and underserved communities. These institutions contribute significantly to regional economic development, especially in non-urban areas where access to formal financial services remains limited. However, the sustainability of rural banks is strongly influenced by their ability to operate efficiently in managing resources and generating financial outputs (Berger & Mester, 1997; Sufian, 2011).

Efficiency has become a central issue in the banking industry due to increasing competition, regulatory pressures, and economic uncertainty. In this context, efficiency reflects a bank's ability to optimize inputs to produce maximum outputs. Data Envelopment Analysis (DEA) has been widely applied as a non-parametric method to evaluate efficiency in financial institutions due to its ability to handle multiple inputs and outputs without requiring a specific functional form (Coelli et al., 2005). Empirical evidence in the Indonesian context shows that rural banks still experience inefficiency, particularly in their intermediation function, indicating suboptimal utilization of financial resources (Wasiaturrahma et al., 2020). Furthermore, capital adequacy has been identified as a key determinant of efficiency, as well-capitalized banks tend to be more stable and capable of improving performance (Fries & Taci, 2005).

Recent developments in the literature emphasize the application of two-stage DEA approaches, which combine efficiency measurement with econometric models such as Tobit regression to identify the determinants of efficiency. This approach allows researchers to link efficiency scores with internal and external factors influencing bank performance more comprehensively (Simar & Wilson, 2007). Several studies have demonstrated that internal variables such as profitability, capitalization, and operational structure significantly affect banking efficiency, particularly in developing economies where institutional conditions vary widely (Sufian, 2011). In addition, efficiency is not static but dynamic, as it evolves over time due to managerial decisions, technological changes, and macroeconomic conditions (Berger & Mester, 1997).

Despite the growing body of literature, several important gaps remain. First, most previous studies focus on national-level banking systems or specific segments such as Islamic banks, while regional-level analyses particularly for rural banks remain limited. This is important because regional characteristics, including economic structure and financial access, can significantly influence banking performance. Second, many studies primarily focus on measuring efficiency without sufficiently analyzing its determinants using a robust two-stage framework, thereby limiting the explanatory power of the results (Simar & Wilson, 2007). Third, there is still a lack of recent empirical evidence capturing post-pandemic banking dynamics, where structural changes in financial systems may alter efficiency patterns, especially in developing economies such as Indonesia (Wasiaturrahma et al., 2020).

To address these gaps, this study employs a two-stage Data Envelopment Analysis (DEA) approach to evaluate the technical efficiency of rural banks in East Java during the period 2021–2023 and to analyze the internal determinants of efficiency using Tobit regression. By integrating efficiency measurement with econometric analysis, this study provides a more comprehensive understanding of both efficiency levels and their driving factors.

The contribution of this study is threefold. First, it provides updated empirical evidence on rural banking efficiency at the regional level in a developing economy, which remains underexplored in the literature. Second, it extends previous studies by applying a two-stage DEA framework that links efficiency scores with internal financial indicators, thereby enhancing the analytical depth of efficiency studies (Simar & Wilson, 2007). Third, it offers practical insights for policymakers and banking practitioners in improving financial performance and operational efficiency. Accordingly, this study aims to measure the

technical efficiency of rural banks and to analyze how internal financial factors such as capital adequacy, credit risk, profitability, and bank size affect efficiency levels.

METHODS

This study adopts a quantitative research design to analyze the technical efficiency of rural banks and its determinants using a two-stage analytical framework. The two-stage Data Envelopment Analysis (DEA) approach has been widely applied in banking efficiency studies as it enables researchers not only to measure efficiency but also to identify the factors influencing efficiency levels in a structured manner (Simar & Wilson, 2007). The first stage applies Data Envelopment Analysis (DEA) to estimate efficiency scores, while the second stage utilizes Tobit regression to examine the factors influencing efficiency. This combined approach is widely used in efficiency studies as it allows for both measurement and explanation of efficiency levels in a comprehensive framework.

Data and Sample

The study uses secondary data obtained from the published financial reports of Rural Banks (Bank Perkreditan Rakyat/BPR) provided by the Otoritas Jasa Keuangan. The observation period covers three years, from 2021 to 2023, ensuring recent and relevant empirical analysis.

The sample consists of 20 conventional rural banks operating in East Java. The selection of the sample is based on data availability and completeness of financial statements during the observation period. This purposive sampling approach ensures consistency and reliability of the dataset used in the analysis.

Variables and Measurement

In the first stage, the DEA model is applied using an intermediation approach, which considers banks as financial intermediaries that transform inputs into outputs. The selection of input and output variables follows prior banking efficiency literature.

The input variables include: (1) capital, representing the financial strength of the bank; (2) interest expenses, reflecting the cost of funds; and (3) other operational expenses, capturing administrative and operational costs. Meanwhile, the output variables consist of: (1) interest income and (2) other operating income, representing the bank's ability to generate revenue from its activities.

In the second stage, the efficiency scores obtained from DEA are used as the dependent variable in the Tobit regression model. The independent variables represent internal bank characteristics, including Capital Adequacy Ratio (KPMM), Non-Performing Loans (NPL), Return on Assets (ROA), and bank size (SIZE). These variables are selected based on their theoretical relevance in explaining banking performance and efficiency.

Analytical Method

In the first stage, efficiency scores are estimated using an input-oriented DEA model under the Variable Returns to Scale (VRS) assumption. The input orientation is chosen because banks have greater control over input utilization than output generation. The VRS model is considered appropriate as it accounts for scale inefficiency and reflects real-world banking conditions where institutions may not operate at an optimal scale.

The input orientation is chosen because banks have greater control over input utilization than output generation. This assumption is consistent with previous studies in banking efficiency, which argue that managerial decisions are more directly related to input management than output expansion (Wasiaturrahma et al., 2020). The DEA efficiency score ranges from 0 to 1, where a value of 1 indicates full efficiency, and values below 1 indicate relative inefficiency compared to other decision-making units (DMUs).

Stage I: Technical Efficiency Analysis of Rural Banks

Technical efficiency analysis is conducted using the Variable Returns to Scale (VRS) model proposed by (Banker et al., 1984), which extends the Constant Returns to Scale (CRS) model. The efficiency measurement in this study is input-oriented, where the inputs consist of capital, other operational expenses, and interest expenses, while the outputs include interest income and other operating income.

The VRS assumption is appropriate because banks or DMUs may not operate at an optimal scale. This approach isolates pure technical efficiency by removing scale efficiency effects, allowing for a more accurate assessment of managerial performance. It also implies that the proportional relationship between inputs and outputs is not constant.

The DEA model can be expressed as a ratio of weighted outputs to weighted inputs:

$$\begin{aligned} \text{Maks } h_s &= \sum_{i=1}^m V_i X_{ij} + U_o \\ \text{Kendala } \sum_{i=1}^m U_i Y_{ir} - \sum_{j=1}^m V_j X_j &\leq 0, r = 1, \dots, n \\ \sum_{j=1}^n V_j X_j &= 1; U_i \geq 0 \text{ dan } V_j \geq 0 \end{aligned}$$

Keterangan:

h_s = efficiency score of bank (s)

n = number of banks

U_i = weight of output (i)

y_{ir} = amount of output (i) produced

V_j = weight of input (j)

X_j = amount of input (j) used

Stage II: Analysis of Factors Affecting Efficiency

In the second stage, Tobit regression analysis is employed to examine the determinants of efficiency by incorporating environmental variables representing internal bank factors. The Tobit model is appropriate when the dependent variable is censored within a specific range. According to (Saraswati, 2016), the Tobit model assumes that the dependent variable is limited (censored), while independent variables are unrestricted, and that classical assumptions such as no autocorrelation, no heteroskedasticity, and no perfect multicollinearity are satisfied.

This approach is suitable because efficiency scores are bounded between 0 and 1. The general Tobit model (Greene, 2008) is expressed as:

$$y_i = \begin{cases} y_i^* & y_i^* > 0 \\ 0 & y_i^* \leq 0 \end{cases}$$

$$y_i^* = x_i^* \beta + u_i$$

In the context of banking efficiency, the model is specified as:

$$y_i^* = \beta_0 + \beta_1 \text{Size} + \beta_2 \text{KPMM} + \beta_3 \text{NPL} + \beta_4 \text{ROA} + u_i$$

Keterangan:

y_i^* = latent efficiency score

β_0 = intercept

$\beta_1 - \beta_4$ = Koefisien variabel independen

Size = total assets

KPMM = capital adequacy ratio

NPL = non-performing loans ratio

ROA = return on assets

u_i = error term

Justification of Methods

The use of DEA is justified due to its ability to handle multiple inputs and outputs without requiring a specific functional form. This makes it particularly suitable for analyzing banking efficiency, where production relationships are complex. Meanwhile, the Tobit regression model is employed to account for the bounded nature of efficiency scores, ensuring unbiased and consistent parameter estimation.

RESULTS AND DISCUSSION

Results

Efficiency Scores of Rural Banks

The results of the first-stage analysis using the input-oriented DEA model under the Variable Returns to Scale (VRS) assumption reveal varying levels of technical efficiency among rural banks in East Java during the period 2021–2023.

Table 1. Efficiency scores of rural banks in East Java (2021–2023)

Banks Name	Efficiency Scores (%)			Average
	2021	2022	2023	
BPR Srikaya	57,87	53,90	42,62	51,46
BPR Rajekwesi	47,32	98,39	100	73,66
BPR Tanah Kondang	100	100	100	100
BPR Tulus Puji Rejeki	40,27	43,20	44,18	42,55
BPR Bina Reksa Karyaartha	100	97,82	100	99,27
BPR Artha Pamenang	80,32	94,30	93,22	89,28
BPR Balongpanggang Sentosa	100	100	100	100
BPR Intan Kita	52,71	45,77	46,10	48,19
BPR Kertosono Saraartha	83,36	100	99,76	94,37
BPR Anjuk Ladang Perseroda	100	100	100	100
BPR Krian Nusantara	100	96,06	100	98,69

BPR Anglomas Indah	52,04	62,09	72,51	62,21
BPR Mentari Terang	100	100	100	100
BPR Semanding	100	100	100	100
BPR Artanawa	69,35	68,99	74,79	71,04
BPR Artha Kencana	71,27	65,93	65,55	67,58
BPR Bumi Jaya	46,60	44,45	52,10	47,72
BPR Bapuri	100	82,04	98,63	93,56
BPR Bintang Niaga	100	100	100	100
BPR Danamas	48,81	43,09	48,96	46,95

Source : Output Maxdea 12.1

The findings indicate that only six rural banks consistently achieved full efficiency (score = 1) throughout the observation period. These banks include BPR Tanah Kondang, BPR Balongpanggang Sentosa, BPR Anjuk Ladang Perseroda, BPR Mentari Terang, BPR Semanding, and BPR Bintang Niaga. Meanwhile, the remaining 14 banks exhibited varying degrees of inefficiency, with several banks showing relatively low average efficiency scores below 0.50.

This variation suggests that not all rural banks are able to optimally utilize their inputs to generate outputs. Inefficient banks tend to experience excess input usage or suboptimal output generation, indicating the presence of managerial or operational inefficiencies.

Determinants of Efficiency

The second-stage analysis employs Tobit regression to examine the determinants of efficiency. The results are presented in Table 2.

Table 2. Tobit regression results

Variable	Coeff.	Std. Error	z-Statistic	Prob.
C	57,63685	6,454741	8,929381	0,0000
KPMM	0,139410	0,033624	4,146166	0,0000
NPL	0,029172	0,285810	0,102069	0,9187
SIZE	4,25E-08	2,80E-08	1,518916	0,1288
ROA	1,779028	0,548380	3,244153	0,0012

Source : Output Eviews 10

The estimation results show that Capital Adequacy Ratio (KPMM) and Return on Assets (ROA) have a statistically significant positive effect on efficiency, as indicated by p-values below 0.05. In contrast, Non-Performing Loans (NPL) and bank size (SIZE) do not have a statistically significant impact on efficiency.

Discussion

Interpretation of Findings

The findings of this study indicate that only a limited number of rural banks operate at full efficiency, while the majority still face inefficiency issues. This result reflects structural and managerial challenges in the rural banking sector, particularly in optimizing resource utilization. From a theoretical perspective, this finding aligns with the concept of technical

efficiency, which emphasizes the ability of firms to maximize output from a given set of inputs.

The significant positive effect of KPMM on efficiency suggests that well-capitalized banks tend to perform more efficiently. Adequate capital allows banks to absorb risks, expand lending activities, and improve operational stability. Similarly, the positive relationship between ROA and efficiency indicates that profitability is closely linked to efficient resource management. Banks that generate higher returns are more likely to allocate resources effectively and operate closer to the efficiency frontier.

On the other hand, the insignificant effect of NPL implies that credit risk does not directly affect efficiency within the observed period. This may be due to effective risk management practices or relatively stable credit conditions among rural banks. Likewise, the insignificance of bank size suggests that larger asset ownership does not necessarily translate into higher efficiency. This finding indicates that scale alone is insufficient without effective management and operational strategies.

Comparison with Previous Studies

The results of this study are consistent with previous research that highlights the importance of capital adequacy and profitability in determining banking efficiency. Several studies have found that well-capitalized banks tend to operate more efficiently due to their ability to manage risks and expand financial intermediation activities. The findings of this study are consistent with prior research on banking efficiency in developing economies. (Wasiaturrahma et al., 2020) found that rural banks in Indonesia are generally inefficient in their intermediation function, which is in line with the results of this study

However, the findings differ from some studies that report a significant relationship between non-performing loans and efficiency. This discrepancy may be attributed to differences in regional characteristics, sample size, and observation periods. In the context of rural banks in Indonesia, local economic conditions and regulatory frameworks may play a role in mitigating the impact of credit risk on efficiency.

Theoretical and Practical Implications

From a theoretical perspective, this study reinforces the relevance of efficiency theory in the banking sector, particularly in developing regions. The findings support the argument that internal financial performance indicators play a crucial role in shaping efficiency outcomes.

From a practical perspective, the results provide important insights for policymakers and banking practitioners. Improving capital adequacy and profitability should be prioritized as key strategies to enhance efficiency (Fries & Taci, 2005). Regulatory authorities, such as Otoritas Jasa Keuangan, may also consider strengthening supervision and providing policy support to improve the performance of rural banks.

Furthermore, bank management should focus on optimizing resource allocation and improving operational efficiency rather than relying solely on increasing asset size. Strategic improvements in financial management and operational practices are essential to achieve sustainable efficiency.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study examines the technical efficiency of rural banks in East Java using a two-stage Data Envelopment Analysis (DEA) approach over the period 2021–2023. The findings reveal that only a small proportion of rural banks consistently operate at full efficiency, while the majority exhibit varying levels of inefficiency. This indicates that many banks have not yet optimally utilized their resources to generate maximum output.

Furthermore, the second-stage analysis using Tobit regression demonstrates that internal financial factors play a significant role in determining efficiency. Specifically, Capital Adequacy Ratio (KPM) and Return on Assets (ROA) are found to have a positive and significant effect on efficiency, suggesting that well-capitalized and profitable banks are more likely to operate efficiently. In contrast, Non-Performing Loans (NPL) and bank size do not show a significant impact on efficiency, indicating that scale and credit risk may not be the primary determinants within the observed context.

Overall, this study contributes to the banking efficiency literature by providing empirical evidence from a regional perspective in a developing economy. The integration of DEA and Tobit regression offers a more comprehensive understanding of both efficiency measurement and its determinants, thereby enriching existing empirical frameworks in financial performance analysis.

Recommendations

Based on the findings, several practical and policy implications can be drawn. Banking institutions should prioritize improving capital adequacy and profitability as key drivers of efficiency. Strengthening financial management practices, optimizing cost structures, and enhancing revenue-generating activities are essential strategies to improve operational performance.

From a regulatory perspective, authorities such as Otoritas Jasa Keuangan are encouraged to design policies that support the sustainability and efficiency of rural banks, particularly through supervisory mechanisms and capacity-building programs. Enhancing governance and risk management frameworks may also contribute to improving efficiency across the sector.

This study is subject to certain limitations, particularly in terms of sample size and the use of internal variables only. Future research is recommended to expand the scope by incorporating external factors such as macroeconomic conditions, institutional quality, and regional characteristics. Extending the observation period and applying alternative methodological approaches may also provide deeper insights into the dynamics of banking efficiency.

Future researchers are recommended to include information on the number of BRI bank customers to illustrate the bank's role in society.

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