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Banking Credit Risk and Efficiency: Some Countries in ASEAN

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Abstract

Banking efficiency is an important strategy to increase competitiveness. The ultimate goal of improving bank performance is the ability of business groups, banks, or countries to excel in competition. Banking can increase competitiveness in various ways, including increasing efficiency. This study presents an empirical analysis of the effect of credit risk on the value of banking cost efficiency in ASEAN. Cost efficiency is measured using panel data of banks in 10 ASEAN countries, employing stochastic frontier analysis and assuming a fixed effect. The efficiency is obtained using the Panel Stochastic Frontier Analysis method. The relationship between loan risk and efficiency is assessed using a linear regression model, specifically, Feasible Generalized Least Squares. In general, banking efficiency in ASEAN exceeds 80%. Another finding from this study is a negative relationship between credit risk and banking efficiency. In this case, the risk that most significantly reduces efficiency is the risk obtained from the loan-to-asset ratio indicator. The greater the risk the bank takes, the lower the cost-efficiency value of the bank. The implications of this research include that bank managers must reduce credit risk to increase the efficiency of bank operational costs.

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INTRODUCTION

The banking industry is the main channel of monetary policy transmission and one of the primary sources of business financing in developing countries. Furthermore, an efficient banking sector is critical for developing financing/credit in developing countries (Anh, 2022) . Furthermore, several compelling reasons exist in the ASEAN context to understand banking efficiency. Banks with a high-efficiency level have an advantage compared to low-efficiency banks. Ultimately, the banks with low efficiency may disappear from the primary market. Secondly, banking competition increases with the financial market liberalization plan, primarily through the implementation of the Asian Banking Integration Framework (ABIF) in 2020. Under ABIF, all banks meeting the Qualified ASEAN BANK criteria have greater flexibility in opening branches in ASEAN countries (Mongid, 2015). This research further enhances the competitiveness of the ASEAN banking sector. Banks are forced to be able to operate closer to the best practice, in this case producing efficiently (Nguyen, 2018) .

Several researchers have conducted bank efficiency studies (Nguyen, 2018, Anh, (2022), Mongid, (2015)). They found that large banks in ASEAN tend to have a higher efficiency than smaller banks. Banks in Singapore have low-cost inefficiency compared to other countries in the ASEAN region. One of the triggers for inefficiency is credit interest. According to final data for 2021, Indonesia has the highest interest in bank loans compared to other ASEAN countries, such as Malaysia, the Philippines, Vietnam, and Thailand (Bank Indonesia, 2022). Based on the Indonesian Chamber of Commerce and Industry (Kadin) records, Indonesia's average interest in bank loans reaches 10.4%. Much higher than Vietnam, which reached 7.7%, the Philippines at 7.1%, Malaysia at 4.9%, and Thailand at only 4.1%.

Bank Indonesia's data shows that the BOPO (operating costs compared to operating income) of banks in Indonesia is still lower than that of banks in ASEAN. Bank BOPO in Indonesia is generally around 80%, whereas ASEAN countries like Singapore and Malaysia have achieved levels as low as 40-50%. With this comparatively low efficiency, national banks might face challenges when competing with banks from other countries during the implementation of the ASEAN economic community from 2015 to 2020. According to Bank Indonesia's 2022 Indonesian Economic and Financial Statistics (SEKI) data, national banking in Indonesia is deemed inefficient as the ratio of operating costs to operating income (BOPO) reaches 83.09%. Meanwhile, the average BOPO in ASEAN banks is significantly lower, at around 30-40%.

Measuring efficiency using BOPO is considered the most effortless approach as it relies on balance sheet data at the end of the period. However, to measure the average efficiency level over time, further studies must combine deterministic analysis with statistical research that considers the stochastic conditions of the data. Here, the SFA/DFA method provides a more consistent measurement as it details the variables for calculating financial ratios, including the BOPO component. On the other hand, the cost frontier approach measures how far an industry, in this case, a bank with full-cost minimization, is relative to other banks. Since the scope of this study includes banks in several ASEAN countries, comparing efficiency using the SFA parametric method is more relevant than calculating BOPO.

However, at the same time, increased competition will increase the possibility of banks carrying out risk-taking in lending. Banks will accept higher risks to gain market share (Ahmad & Luo, 2010). Of course, increasing credit risk will increase banking operational costs. For this reason, it is necessary to see whether credit risk influences the efficiency of banks in ASEAN. The Basel Committee (2001) defines credit risk as the possibility of losing part or the total value of a loan due to the risk of default. Furthermore, the Basel Committee (2001) has stated that credit risk is the most dominant risk in banking. The greater the bank's exposure to credit risk, the greater the

tendency for a bank to experience a financial crisis, and vice versa (Ollivaud & Turner, 2014).

Most existing literature does not consider risk factors affecting efficiencies, such as Arif & Ahmad (2020), Nguyen (2018), Sari et al., 2018; Chan et al., (2016). Even though, Sapci & Miles 2019) states that banking efficiency is considered lacking if it does not pay attention to risk factors. According to Ahmad & Luo (2010), loans are usually used as output variables in an intermediate approach to model the production function of a bank. Meanwhile, the risk factors are proxied by using non-performing loans data.

The final goal of performance improvement is the ability of business groups, banks, or countries to compete. Various researchers, such as Anginer et al. (2014) and Berger et al. (2009), explain that banking can increase competitiveness with various ways of increasing efficiency. The contribution of this paper is to fill the research gap where previous research related to banking efficiency comparisons was mainly carried out in developed countries, such as America and the European Union. Furthermore, this study looks at important credit risk factors rarely associated with banking efficiency (Ahmad & Luo, 2010). The research aims to address the above problems and will be divided into two stages. In the first stage, the banking efficiency value is calculated using the stochastic frontier analysis (SFA) method. Subsequently, the study examines the effect of credit risk on banking efficiency.

This study focuses on the discussion of cost minimization. In the research of Mongid (2015) and Nguyen (2018), it is explained that the cost function approach is widely used to explain the efficiency of companies operating in a regulated environment. The cost function measures the minimum cost required to produce a given level of output and some fixed input price. The cost function states that all input prices must be greater than zero w >> 0.

$$c(w,y) \equiv \min_{x \in \mathbb{R}_+^n} w\,x\,s.t.\,f(x) \geq y \quad \text{.....(1)}$$

If x(w,y) Solve the cost-minimization problem.

$$c(w,y) = wx(w,y) \quad \text{.....(2)}$$

This function is the minimum cost for producing y output units or the cheapest cost. Mongid (2015) states that the labor price is the wage rate (w). In comparison, the output in several studies is divided into the value of loans and investment assets (Nguyen, 2018).

Furthermore, Ariff & Can (2008) and Mongid (2015) explained that (referring to the rules in the cost frontier function) all input and output variables are expected to be positive and significant so that the model can be said to be a good model. This model means that input price variables such as the price of labor, the price of capital assets, and the price of borrowed funds are expected to positively affect the total cost of banking. The greater the three input prices will further increase the total costs incurred by banks in operating.

Greene (2010) in Ekananda (2016) defines efficiency as the characteristic of the relationship between empirically observed production and ideal or potential production. Efficient means that all inputs can be used or produced into outputs without anything remaining. The concept of efficiency used in this study uses several references such as Kallio & Hardoroudi (2019) and Sapci & Miles (2019) and other studies. Below, the explanation of this concept is discussed. Kallio & Hardoroudi (2019) explained that efficiency in a company consists of two components: technical efficiency and allocative efficiency. Technical efficiency describes the company's ability to produce maximum output from available inputs.

Meanwhile, Ahmad & Luo (2010) differentiate the concept of efficiency into two categories: productive and economical. Product efficiency measures the ratio of output levels. A firm must maximize output at a certain level or minimize inputs for a specific output level to be efficient. Meanwhile, economic efficiency is the optimal selection of the level and combination of inputs and outputs based on the response of market prices. Economic efficiency requires the achievement of productive efficiency and allocative efficiency together (Karagiannis & Kellermann, 2019).

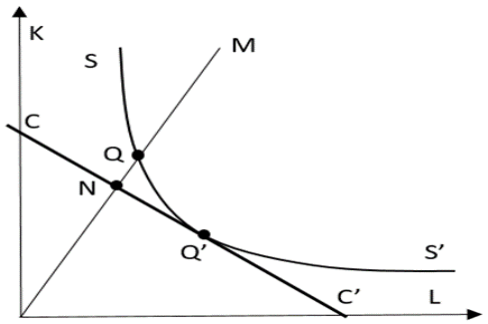

Figure 1. Technical and Allocative Efficiency
Source: Zhao & Xu, 2013

A deeper explanation of economic efficiency is discussed by Zhao & Xu (2013) and Ye et al. (2012), who divide the concept into cost efficiency, standard profit efficiency, and alternative efficiency. Cost efficiency measures the closeness of the costs incurred by the best bank to produce the same output under the same conditions. The closer the efficiency value of a bank to the best bank, the higher the efficiency value, and vice versa (Ariff & Can, 2008).

The last approach is alternative profit efficiency, the latest development combining the two previous concepts. In this approach, efficiency is calculated by measuring how close a bank is to obtaining maximum profit at that level of output (Karagiannis & Kellermann, 2019). According to Coelli et al. (1998), economic efficiency can be classified into two types: technical efficiency and allocative efficiency. The technical efficiency of a company can be seen from how the company uses some inputs to get the maximum output (a lot). The company can be considered technically efficient if it can produce the most output from its input. Allocative efficiency can be seen in how a company optimizes the composition of inputs with certain input price level conditions.

Research on the efficiency of other banking institutions conducted by Zhao & Xu (2013) defines efficiency into scale efficiency, scope efficiency, pure technical efficiency, and allocative efficiency. Scale efficiency measures the level of efficiency associated with the scale of the bank's business. The scale of this business is evident from the number of assets. Secondly, scope efficiency is an approach that measures bank efficiency based on the scope of the bank's business, estimating efficiency by considering the level of coverage of economies. When a bank offers more products, it is considered more efficient than specialist banks. Conversely, specialist banks may be more efficient in scope diseconomies than banks with a wide range of products (Mataba & Aikaeli, 2016).

Ekananda (2016) explains that a company is assumed to have two types of inputs (K and L) to produce an output (y). The line SS' (isoquant) describes the most efficient combination of the number of inputs the company can use to produce output (y). In a set of input prices on the line CC' (isocost) represents various combinations of input quantities that make the same level of expenditure. M represents the two input factors (K, L) for each unit of output made. If the firm aims to produce a certain output (y) at the least cost, then the optimal combination of inputs is at point Q'.

Meanwhile, if the company wants to produce with various inputs at point M, this condition is considered technically inefficient and allocative. First, this condition is technically inefficient (inadequate) because it should be more efficient by producing using fewer combinations of inputs at point Q compared to output combinations at point M. The OQ/OM ratio can calculate the level of technical efficiency.

Secondly, this condition is allocative inefficient because the company should be able to produce the same amount at a lower cost if the company produces using a combination of inputs at point Q' than at point Q. The ON/OQ ratio can calculate the level of allocative efficiency. In general, input inefficiency can be calculated by the ON/OM ratio, which corresponds to the technical efficiency and allocative efficiency (OQ/OM ON/OQ). These ratios are from zero to one, where a value of 1 indicates that the company is producing at highest efficiency level.

Karagiannis & Kellermann (2019) suggest three approaches to measure the level of efficiency in the banking industry: the production approach, the intermediation approach, and the modern approach. The production approach describes bank activities as a service to depositors

and debtors, using inputs to generate outputs. Inputs encompass traditional production factors such as land, labor, and capital. Meanwhile, outputs comprise interest income and income derived from sources other than interest. While this approach recognizes the multi-product activities offered by banks, it falls short of capturing a more comprehensive measurement of production factors.

Kallio & Hardoroudi, D. (2019) also explained that economic efficiency consists of two components: technical efficiency and allocative efficiency (Zhao & Xu, 2013). This concept is then discussed by Sapci & Miles (2019), where efficiency is divided into three economic efficiency concepts: cost efficiency, profit efficiency, and alternative profit efficiency.

The second approach is the intermediation approach. In this approach, financial capital is the input, namely third-party funds and funds collected from financial markets. In contrast, the output is derived from the volume of loans and investments (Ollivaud & Turner, 2014).

Zhang & Matthews (2012) conducted research on banking efficiency in ASEAN. This study tries to calculate the efficiency value of all banks in ASEAN. The data used are two outputs (credit and receipts on other asset investments) and three inputs (labor prices, physical capital prices, and financial capital prices). The results of efficiency calculations show that banking in Thailand has the highest cost efficiency, followed by banking in Singapore, Malaysia, and Indonesia, and last is banking in the Philippines.

The discussion on efficiency and its determinants is carried out by Gardener et al. (2011) in six South East Asian Banking countries. This study uses two strategies to answer research questions: the Stochastic Frontier Analysis method to calculate efficiency values and the OLS method to see what factors significantly influence the formation of efficiency in a bank. The results of this study are that the six countries studied have banking cost efficiency values at a relatively low level. Furthermore, this study states that banks with foreign ownership have the highest level of efficiency (Kallio & Hardoroudi, D., 2019).

Other research discussing the factors that affect efficiency in the banking sector, especially in ASEAN, was conducted by Gardener et al. (2010). This study calculates the DEA's efficiency level and continues to find its determinants using Tobit regression. The research divides banking into three groups: private and government banks. Similar things have been done by Anh (2022) and Nguyen (2018) with the scope of banking in ASEAN. This study uses the DEA method to calculate efficiency and the regression method to determine the efficiency level's determinants.

Risk in banking is defined as a negative impact on profits by several sources of uncertainty (Tan, 2016). Risk is the uncertainty that may lead to a reduction in income or wealth in the financial industry. In other words, uncertainty is only associated with a potentially negative outcome.

Furthermore, Tan (2016) categorizes several key banking risks, including credit risk, interest rate risk, market risk, liquidity risk, operational risk, exchange rate risk, and other risks such as country risk, settlement risk, and performance risk. In the world of banking, there are many risks to be faced. However, this research will focus on credit risk. This risk is due to a study conducted by the Bassel Committee, which considers credit risk to be the risk that is considered to have the most significant impact in the banking world (Marcelin et al., 2022).

Credit risk is a significant concern, leading governments and regulators to continuously refine methods for determining the appropriate amount of capital banks must hold. This risk is substantial because even if a few priority customers fail to pay, it can result in substantial losses and potential insolvency. At least two key indicators are used to assess costs or losses arising from late or failed loan payments to banks: the loan loss reserve and the loan-to-asset ratio. According to Tan (2016) and Anh (2022), loan loss reserves estimate the number of bank losses to cover uncollectible bad loans. From a risk perspective, Altunbas et al. (2007) and Anginer et al. (2014) define that loan loss reserves are part of total assets used to measure banking risk from an

accounting standpoint. A higher reserve level indicates a greater banking risk. Meanwhile, the loan-to-asset ratio indicator can also be used to view banking risk where fast loan growth is considered to increase risk and have a negative impact on banking capital and efficiency (Altunbas et al., 2007).

Relationship between Credit Risk and Banking Efficiency. Research on the relationship between efficiency and bank risk in which bank risk is measured by several variables, such as that conducted by (Maudos et al., 2002), who use the Loan asset ratio, where a bank with a higher LAR ratio is considered to be more profit-efficient but not cost-efficient. However, there will be higher fees when the loan defaults. When banks are more willing to take credit risk, the control over costs is reduced.

In addition to LAR, also against Altunbas et al. (2007), the loan-loss reserves (LLR) found a positive and significant relationship between the level of efficiency and the level of risk taken by banks. Kapuściński (2017), with his research in Poland, found the opposite result: banks with higher risk-taking indicated by loan-loss provisions and the loan-to-asset ratio have lower efficiency levels. However, they are more efficient when risk is measured using ROA volatility (as opposed to the research results of Altunbas et al., (2007).

Although still very limited, some studies extend the study of bank efficiency by integrating risks related to bank operations into their analysis, assuming that risk will impact the bank's overall performance. Because risk is not explicitly considered in the production and cost function models, banks that operate with risk aversion are often considered inefficient, while banks that produce lower quality than others are considered efficient. Therefore, some authors, such as Altunbas et al. (2000) and Altunbas et al. (2007), try to accommodate bank risk and inefficiency.

Regarding the banking efficiency determinants research, Gardener et al. found that banks with larger asset values have higher efficiency levels in profit and cost (Grigorian & Manole, 2006). On the other hand, Maudos et al. (2002) found that banks with larger sizes tend to have lower profits but higher cost efficiency. However, several previous studies found that bank size did not significantly affect cost efficiency (Le et al., 2020).

Previous studies on the correlation between bank capital and efficiency by Carlson et al. (2013), Fries & Taci (2005), and Grigorian & Manole (2006) conducted in the USA and Eastern Europe show that banks with higher capital levels have higher levels of efficiency. On the other hand, research in Western European countries found that inefficient banks have more significant amounts of capital Altunbas et al., (2007) and Ahmad & Luo, (2010).

Based on the research problem and literature background, we strongly form a hypothesis for all banks in ASEAN countries. H1: Increasing bank loans in ASEAN countries will increase Costs. H2: The greater the banking assets in ASEAN countries, the lower the banking efficiency. and H3: Reducing bank credit risk in ASEAN countries will increase banking efficiency.

RESEARCH METHODS

The following strategy is used to answer this research question. The first stage is to calculate banking efficiency in ASEAN using the stochastic frontier method. Then the next step is to estimate the effect of risk on banking efficiency in ASEAN (Anh, 2022). In calculating the efficiency using the stochastic frontier, there are several steps. First, perform a regression on the cost efficiency model. Then predict the inefficiency value resulting from the previous regression. This value is then converted into the efficiency value for each company and the research period (Mataba & Aikaeli, 2016). The general model for the stochastic frontier model (eq. 3) on panel data is a development of the model with the previous cross-section data as follows: Ekananda (2016):

$$y_{it} = \beta_0 + \sum_{j=1}^{k} \beta_j x_{jit} + v_{it} - s u_{it} \quad \text{..... (3)}$$

Where i = 1, 2, ..., N and t=1, 2, ..., T. The variable s for the set of equations s=1 for the

production function. While s = -1 for the cost function. The SFA method has two types of analysis for panel data. The first analysis method is time-invariant, and the second is time-varying inefficiency/decay. In time-varying inefficiency, the effect of inefficiency is calculated by the following formula (eq.4):

$$u_{it} = exp\{(-\eta(t - T_i)\}u_i \quad \text{.....(4)}$$

If $\eta > 0$, then the level of inefficiency will decrease over time to the base level. If $\eta < 0$ degrees of inefficiency will increase over time. This degree is because in the last period (t=Ti), company i contains a base level of inefficiency. If $\eta = 0$, the time-varying inefficiency/decay formula becomes time invariant model. Equation (4) becomes equation 5:

$$u_{it} = exp\{0\}u_i = u_i \quad \text{.....(5)}$$

Research that wants to analyze inefficiency at the level of individual characteristics can only do so using time-invariant measures. Meanwhile, if the study intends to explore the different aspects throughout the time of observation and individuals, we can use the time-varying inefficiency method.

The stochastic Analysis Frontier is divided into two approaches: production frontier and cost efficiency (Ariff & Can, 2008). It is necessary to make assumptions about its functional form to estimate the stochastic frontier model. Banking is an industry with various products, so we cannot carry out The production function specification cannot be carried out. Therefore, the author recognizes the importance of analyzing from two sides: cost efficiency and profit.

Referring to the research of Maudos et al. (2002), the goal of maximizing profit is a more comprehensive source of information for managers because it does not require goods and services to be produced at a minimum cost but requires an effort to maximize revenue. In addition, as Zhao & Xu (2013) stated, cost inefficiency and profit level do not have to be related. For this reason, the managerial side should be able to analyze from both sides, namely cost efficiency and profit.

Economic efficiency can be calculated using two methods, namely, the parametric method and the non-parametric method. Stochastic Frontier Analysis (SFA) and Distribution Free Approach (DFA) are the parametric methods used in calculating the efficiency value. The SFA method assumes that inefficiency follows an asymmetric distribution which generally is half-normal, while random error follows a symmetric distribution which is commonly referred to as the standard normal distribution (Kallio & Hardoroudi, D., 2019). The DFA method assumes that there is a stable efficiency over time. This method uses distribution assumptions in calculating inefficiency and believes that the average random error will disappear over time (Sapci & Miles, 2019).

This study uses the Stochastic Frontier approach, developed by Kallio & Hardoroudi (2019), to estimate cost inefficiency. The SFA approach because it uses a company-specific regression method. The stochastic cost frontier has the following log form:

$$TC_{it} = f(P_{it}, Y_{it}, Z_{it}) + v_{it} + u_{it} \quad \text{..... (6)}$$

Where TC_{it} is the operational and financial costs of a bank i in year t, P is a vector of input prices, Y is a vector of outputs, and Z is a set of control variables. This approach breaks down the error term into two components. First, v_i, is associated with random fluctuations, which are assumed to follow a symmetrical normal distribution around the frontier ($v_i \sim N(0, \sigma_v^2)$ and capture phenomena outside management's control or bad (good) luck or error size. u_i, calculates inefficiencies in the company, for example, factors that management or weaknesses in managerial performance can control.

This research consists of two stages. First, calculate the cost efficiency of the banking industry in ASEAN using Stochastic Frontier Analysis (SFA). The SFA approach is very commonly used in measuring banking efficiency. This study uses the cost function model used by Coelli et al. (1998), (Nguyen, 2018), Anh (2022), and Mongid (2015) as follows:

$$TC = TC(Q_i, P_i) + \varepsilon_i \quad \text{.....(7)}$$

Where TC is the total cost, Q_i is the vector of the output of the i-th firm, P_i is the vector of the input prices of the i-th firm—efficiency Calculation on the Stochastic Frontier Method. Technical efficiency (TE) depends on input and output factors, so TE is a function of x and y. The following is an explanation from Ekananda (2016), which is derived from the writings of Greene (2010) in the book Pesaran & Schmidt (2008). The empirical measurement of TE(x,y) requires a transformation function. For the basic description of this model, we only pay attention to one input factor. $Y \leq f(x)$. This model shows the inefficiency of the production to be measured by f(x) against the production of Y. This indicates that the amount of output produced must be equal to or less than the number of inputs used. The inequality gives the idea of measuring TE as follows: $TE(x,y) = \frac{y}{f(x)}$. The development for the econometric model becomes $y_i = f(x_i,\beta)TE(x_i,\beta)$, where $0 \leq TE(x,\beta) \leq 1$ is the parameter to be estimated, and i is the N companies to be observed (Ekananda 2016). The linear form of this model becomes equation (8).

$$\ln y_i = lnf(x_i,\beta) + lnTE(x_i,\beta)$$

$$\ln y_i = lnf(x_i,\beta) - u_i \quad \text{.....(8)}$$

Where u > 0 as a measure of technical efficiency. In other notations, it can be written as:

$$\ln q_i = \beta_0 + \beta_1 \ln x_i + v_i - u_i$$
$$ln\ q_i = \exp(\beta_0 + \beta_1\ ln\ x_i) \times \exp(v_i)$$
$$\exp(u_i) \quad \text{.....(9)}$$

Where $q_i = \exp(\beta_0 + \beta_1\ ln\ x_i)$ is a deterministic component, $\exp(v_i)$ is noise, and $\exp(u_i)$ is inefficiency. So, technical efficiency can be written as equation (10).

$$TE_i = \frac{q_i}{\exp(x_i'\beta + v_i)}$$

$$TE_i = \frac{\exp(\beta_0 + \beta_1 \ln x_i + v_i - u_i)}{\exp(x_i'\beta + v_i)}$$

$$TE_i = \exp(-u_i) \quad \text{.....(10)}$$

Equation (10) means that TE (technical efficiency) is obtained by comparing each bank in the sample with the bank with the highest efficiency level (inefficiency close to zero). Data processing will use STATA software.

The way to predict uit is by giving a command to STATA in the form of predicting a new name, te. If the uit value has been obtained, the next step is to convert the uit value into the value of technical efficiency. We use the exponential of the negative efficiency. The STATA command generates te=exp(-uit). After getting the regression results, predictions are made on the technical inefficiency of each bank in ASEAN (ASEAN Banking Efficiency Level). In this condition, the smaller the predicted value of technical inefficiency coming from the bank, the more efficient the bank is considered to be. The greater the efficiency value, the more efficient a bank will be.

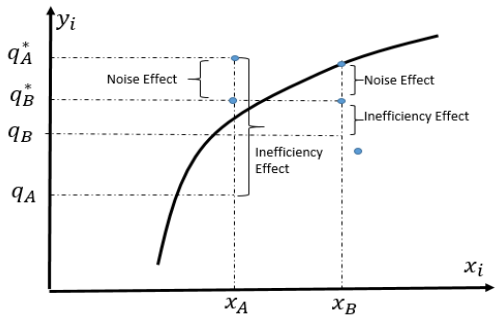

Figure 2. Frontier stochastic graph.
Source: Greene, 2010

Where exist y_i are :

$$q_A^* = \exp(\beta_0 + \beta_1 Ln(x_A) + v_A$$
$$q_B^* = \exp(\beta_0 + \beta_1 Ln(x_B) + v_B$$
$$q_B = \exp(\beta_0 + \beta_1 Ln(x_B) + v_B - u_B$$
$$q_A = \exp(\beta_0 + \beta_1 Ln(x_A) + v_A - u_A \quad \text{.....(11)}$$

The deterministic frontier results from the conventional regression we have studied. The residuals are divided into noise and inefficiency effects through the stochastic frontier. Point X is the data; the residual is divided into noise and inefficiency components (see equations 9 and 10). The point • is the position of the noise formed, which results in a directed regression prediction line. The drift is noise if there are no inefficiencies (Greene, 2010; Kallio & Hardoroudi, D., 2019).

Banking Efficiency Model. This study assumes that banks collect third-party funds (deposits) to be converted into loans using labor and capital. The empirical model used to calculate the stochastic cost frontier using the Banking Production Cost Model (Model I) is:

$$lnCost_{it} = \alpha + \beta_1 lnLoan_{it} + \beta_2 lnInvI_{it} + \beta_3 lnStExp_{it} + \beta_4 lnPPC_{it} + \beta_5 lnPBF_{it} + e_{it} \quad \text{.....(12)}$$

Where i is the bank identity number (i=1,2,…,312), j is the country identity number (j=1,2,…,10), and t is the period 2012 - 2017 (t=12,…, 17). The details of the variables used are shown in Table 1. Ln notation for natural logarithm.

The data used in this study is banking panel data of ASEAN countries (10 selected countries) from 2012 - 2021. The ten ASEAN countries in question are Indonesia, Malaysia, Vietnam, Thailand, Singapore, Cambodia, Brunei Darussalam, Philippines, Myanmar, and Laos. The source for obtaining these data is the BankScope database from BVD-IBCA.

The data from Bank Scope for 10 ASEAN countries consists of 754 banks. We limit the data with two sample criteria using commercial banks, cooperatives, and commercial banks with 1548 observations from 312 banks in 10 countries in 2012-2021. In contrast, the data used in data processing to see the relationship between credit risk and efficiency using 1331 observations and 281 banks from 10 ASEAN countries in 2012-2021.

Table 1. Data for Banking Efficiency Model (Model I)

Variable	Remarks	Expected	Remarks
Cost	Total costs	(+)	Total costs incurred by the bank to operate for a year.
Loan	Loan	(+)	A loan given by a bank for a year.
InvI	Investment Income	(+)	Income on investment assets
StExp	Price of labor	(+)	The ratio of Staff expense to Total Assets
PPC	Physical capital price	(+)	Ratio (non-interest expense – staff expense) to fixed assets
PBF	Price of third-party funds	(+)	Interest expense ratio to all third-party funds / managed.
GDP	Gross Domestic Product	(+)	Value of GDP per capita of a country per year

Source: Data Processed, 2023

The definition of the variables used in this study is the intermediate approach used in the studies of (Altunbas et al., 2007; Altunbaş et al., 2001; Anh, 2022; Mongid, 2015). This approach is quite widely used in the study of banking efficiency (Alzubaidi et al., (2012); Chan et al., 2016)).

We should obtain the price of labor from the personnel expense ratio to the number of workers. However, because not all data on the number of employees are available, it is measured using the ratio of personnel expense to total assets (Ahmad & Luo, (2010); Maudos et al., (2002)). Meanwhile, the price of physical capital is the ratio of other non-interest expenses to fixed assets, as explained by Nguyen, 2018; Ollivaud & Turner (2014) and Zhao & Xu (2013); another non-interest cost is calculated from operating expenses (non-interest expense minus staff expense). Then, the price of borrowed funds is the ratio of the interest paid on all funds. Lastly, the total cost is the sum of personnel expenses, other non-interest payments, and paid interests.

Credit Risk Model on Efficiency. Referring to Gardener et al. (2011), Ekananda (2016), and Greene (2010), second-stage regression to test the determinants of cost efficiency is calculated by the following equation (13), (Model II):

$$lnEFF_{it} = \alpha + \delta_1 lnSIZE_{it} + \delta_2 ROAA_{it} + \delta_3 Return_{it} + \delta_4 TLTA_{it} + \delta_5 LRGL_{it} + \delta_6 LLPL_{it} + \varepsilon_{it} \quad \text{.....(13)}$$

Where i is the number of banks observed, and t is the number of years of observation.

Table 2. Data for Credit Risk Model (Model II)

Variable		Remarks	Exp. sign
LnEFF	Dependent	Skor Efficiency	
LnSIZE	Independent	Total asset	(+)
ROAA		The ratio for net income to assets	(-)
Cap		The ratio for total equity to assets	(-)
TLTA		The ratio for the Total Loan to Assets	(-)
LRGL		The ratio for Loan Loss Reserve to Gross Loan	(-)
LLPL		The ratio for Loan Loss Provision to Loan	(-)

Source: Data Processed, 2023

After we define Model I and Model II, the proof of the hypothesis is based on the proof of the statistical hypothesis as follows. H1: $H_0 : \beta_1 = 0$, $H_1 : \beta_1 \neq 0$, where Ho's rejection will prove: Generally, an increase in bank loans in ASEAN countries will increase Cost.

H2: $H_0 : \delta_1 = 0$, $H_1 : \delta_1 \neq 0$, where Ho's rejection will prove: Generally, ASEAN countries' more significant banking assets will reduce banking efficiency.

H3: $H_0 : \delta_5 = 0$, $H_1 : \delta_5 \neq 0$, where Ho's rejection will prove: Generally, decreasing banking credit risk in ASEAN countries will increase banking efficiency.

Sapci & Miles (2019), Gaganis & Pasiouras (2009), and Kallio & Hardoroudi, D., 2019) found that bank size had a positive and significant effect on efficiency scores. At the same time, Le et al. (2020) found that banks with larger sizes tend to have lower profits but with higher cost efficiency. The studies of Karagiannis & Kellermann (2019); Ollivaud & Turner (2014)) did not find a significant relationship between bank size and efficiency scores. However, according to Kallio & Hardoroudi (2019), the larger the bank, the weaker it tends to spread costs, causing lower cost and allocation efficiency.

$$SIZE_{it} = Total\ Assets_{it} \quad \text{.....(14)}$$

Research by Mataba & Aikaeli (2016) and Zhao & Xu (2013) on bank profitability (ROA) and efficiency show that profitability has a significant and positive effect on efficiency. The following ROAA calculation:

$$ROAA_{it} = \frac{Net\ Income_{it}}{Average\ Assets} \quad \text{.....(15)}$$

Where:

$$Avg.Asset = \frac{Total\ Assets_{it-1} + Total\ Assets_{it}}{2} \quad \text{.....(16)}$$

The study by Sapci & Miles (2019), Gaganis & Pasiouras (2009), and Kallio & Hardoroudi (2019), which examined the relationship between bank capital and the level of efficiency, found a positive and significant relationship, while the opposite result was shown by research conducted by Altunbas et al., (2007). They found negative and significant relationship between bank capital and the level of efficiency. The calculation of the variable bank capital is as follows:

$$TLTA_{it} = \frac{Total\ Loan_{it}}{Total\ Assets_{it}} \quad \text{.....(17)}$$

The ratio for Loan Loss Reserve to gross Loan:

$$LRGL_{it} = \frac{Loan\ loss\ reserves_{it}}{Gross\ loans_{it}} \quad \text{.....(18)}$$

The ratio for loan loss provision to Loan:

$$LLPL_{it} = \frac{Loan\ loss\ provision_{it}}{Total\ loans_{it}} \quad \text{.....(19)}$$

When banks are more willing to take credit risk, the control over costs is reduced. In addition to TLTA, Anh (2022), with loan-loss reserves (LRGL), also found a positive and significant relationship between the efficiency level and the level of risk banks take. The opposite finding by Kapuściński (2017) in Poland found that the risk measured by the loan-loss provision and the loan-to-asset ratio had a negative and significant effect on efficiency.

RESULTS AND DISCUSSION

This section will analyze banking convergence in ASEAN from 2012 to 2021. The study is divided into several stages. The first is an analysis of the calculation of the inefficiency scores of all banks in ASEAN. Second, it will discuss whether credit risk will affect the value of banking efficiency. The data used in this study covers ten ASEAN countries, with the data distribution as shown in Table 3.

The description explains the banking situation in 10 countries in ASEAN. The largest Total Cost (TC) is Thailand (THA), followed by Vietnam (VIE). In the study of the efficiency index of the balance sheet, Cambodia and Laos are the most efficient. The lowest efficiency is in Thailand and Vietnam. If we look at the level of profit (ROAA), the highest was obtained by Vietnam, Thailand, and Cambodia. The lowest ROAA is in Indonesia, Singapore, and the Philippines. Meanwhile, Indonesia has the lowest capital in terms of Capital (CAP). From all statistical data, almost all variables, Indonesia occupies low position, including Loans, Income on investment assets, Price for Physical Assets, Price of Borrower Funds, Efficiency Score, Ratio for Loan to Tot Assets, Tot Loan Reserves to Gross Loan and Total Loan Provision to Total Loan.

Table 3. Data Description

Label	Unit	INA	MAL	VIE	THA	SIN	KAM	BRU	PHI	MYA	LAO
TC (in mil)	USD	1.24	46.68	168.21	4.49	1.60	143.69	1.88	98.92	133.20	89.66
Loan (In mil)	USD	20.57	705.32	1,740.59	48.87	17.82	3,028.04	14.15	3,288.59	2,481.18	964.26
InvInc (in mil)	USD	23.20	400.43	473.15	6.48	4.68	1,087.30	4.16	1,697.12	818.39	422.72
StExp	%	0.09	1.97	10.25	2.22	0.73	1.84	0.86	0.76	1.69	1.28
PPC	%	14.19	346.43	1,195.37	240.08	58.88	16,174.94	56.41	1,317.09	664.76	509.75
PBF	%	0.05	2.55	27.18	8.21	2.00	7.77	2.15	12.83	7.40	9.90
Eff	index	0.873	0.878	0.857	0.866	0.881	0.909	0.886	0.872	0.865	0.892
Assets (in mil)	USD	47.84	1,393.40	2,704.53	77.80	30.26	4,632.96	25.17	5,591.25	3,792.02	1,540.14
ROAA	%	16.52	222.43	778.01	265.65	55.17	260.81	83.36	67.30	238.70	95.20
CAP	%	1.51	20.88	79.96	24.37	10.41	34.63	7.53	11.15	29.67	15.38
TLTA	%	5.13	78.37	341.98	73.83	28.96	163.21	20.20	31.46	111.57	83.49
LRGL	%	41.05	671.08	1,039.73	273.49	98.75	820.99	69.75	236.47	904.12	226.77
LLPL	%	10.50	2.77	20.29	5.10	3.37	18.07	4.11	2.13	6.13	3.09

Source: Data Processed, 2023

This study's results align with Maudos et al. (2002), who examined 15 European countries during 1993-2002. Overall, the results showed a stable efficiency value for all samples during the study period. Meanwhile, Weill (2009) showed increased cost efficiency in European countries from 1994-2005. Altunbas et al. (2007) and Ahmad & Luo (2010) also showed increased cost efficiency in European banks between 1989 and 1997. Casu and Girardone (2009) found a slight increase in cost efficiency in European savings banks in 1989-1996. They show a n increase in technical efficiency between 1993-1997 in five European countries. Saha et al. (2015) and Nguyen (2018) found more mixed results in Malaysia between 1993-1997.

The next step is to process the efficiency value from equation (9) to become the dependent variable in equation (10). The most appropriate individual effect is obtained by testing the choice of the model between the Common Effect (as H0) versus the Fixed Effect. The test results show that individual effects occur in banking data in ASEAN countries (Table 4)

Table 4. Test for Panel Data Estimation

Test for	F or Chi	Prob	Result
Common vs. Fixed Effect : Test of H0: Common Effect	F(312, 1229) = 2.03	0.00	Reject H_0
Hausman : Fixed Effect vs. Random Effect Test of H0: Difference in coefficients not systematic	chi2(6) = (b-B)' [(V_b-V_B)^(-1)](b-B = 0.98	0.99	Accept H_0

Source: Data Processed, 2023

The process of obtaining efficiency values is obtained by conducting a regression on the input and output variables. The data in this study is an imbalanced panel where not all years can be filled with the same number of banks in each country. The results of the regression (equation 11) are as follows:

Table 5. Stochastic Frontier Analysis Regression Results (Model I)

Label		Coef	Sig	Remarks
LnCost	Dependent			
LnLoan	Independent	0.653274	0.000	(+)Appropriate
Ln InvI	Independent	0.176080	0.000	(+)Appropriate
lnStExp	Independent	0.313849	0.000	(+)Appropriate
lnPPC	Independent	0.030964	0.000	(+)Appropriate
lnPBF	Independent	0.149561	0.000	(+)Appropriate
Cons		129.8338	0.000	
Wald chi2(6)	5614.19		N of obs	1,548
Prob > chi2	0.0001		N of groups	313

Source: Data Processed, 2023

The processing results of the cost model used in the frontier analysis (equation 9) are pretty good at explaining the total cost-dependent variable (TC). It is sufficient to use explanatory variables as independent influencing the dependent variable. The Wald value can see in the simultaneous test. The probability value is 0.000 (Table 5).

In this case, banking output is represented by the average value of loans (loans) and investment assets in each bank in the 10 ASEAN countries. The loan variable significantly affects the total cost of banking. Finally, the results of P IzI < 0.01, which is 0.000. Meanwhile, the relationship between these output variables and total banking costs is positive—this statement is based on the results of calculating the coefficient on the average loan, which is positive. An increase in a bank's loan will cause an increase in total banking costs. The regression results on output follow the existing theory: when output increases, total costs will increase Ahmad & Luo, (2010); Maudos et al., (2002). We prove hypothesis H1. In general, increasing bank loans in ASEAN countries will increase costs.

The following banking output variable is the value of investment assets (Assets). From the regression results, in terms of value, investment or other earning assets significantly influence total banking costs. The increase in bank investment assets will increase the banking cost. The regression results on output follow the existing theory; the total cost will increase if output increases.

The price of labor, physical capital, and third-party funds (SeExp) are used as a proxy for bank input. The price variable for labor in each bank in the 10 ASEAN countries significantly affects the total cost of banking. An increase in the price of labor for a bank will cause an increase in total banking costs. The regression results on input follow the existing theory; if the input increases, the total cost will increase.

Another input variable is the price of physical capital in each bank in the 10 ASEAN countries (PPC). This variable significantly affects the total cost of banking. An increase in the price of physical capital in banks will increase the total cost of banking. The regression results on input are under the existing theory; if the input increases, the total cost will increase.

The final input variable is the price of third-party funds (PBF). The variable price of third-party funds in each bank in the 10 ASEAN countries significantly affects the total cost of banking. The increase in the price of third-party funds at the bank will increase the total cost of banking. The regression results on input follow the existing theory; if the input increases, the total cost will increase.

The process of obtaining the parameter value of the control variable determines the efficiency value. The data in this study is an imbalanced panel where not all years can be filled with the same number of banks in each country. The results of the regression (equation 12) are as Table 6:

Table 6. Regression Results of the Effect of Credit Risk on Efficiency (Model II)

Label		Coef	Sig	Remarks
Eff	Dependent			
Size	Independent	-0.0025003	0.028	(-)Appropriate
ROAA	Independent	-0.0002292	0.880	(+)
Capital	Independent	0.0397359	0.019	(+)Appropriate
TLTA	Independent	0.0033174	0.784	(+)
LRGL	Independent	-0.0010309	0.004	(-)Appropriate
LLPL	Independent	0.0056519	0.514	(+)
Cons		-0.1034702	0.000	
Wald chi2(6)	27.85		N of obs	1,548
Prob > chi2	0.0001		N of groups	313

Source: Data Processed, 2023

The banking lnSize variable is represented by the log of Total Assets in each bank in 10 ASEAN countries. From the regression results in the table above, it is known that this variable significantly affects the value of banking efficiency. Increasing lnsize will reduce cost efficiency. We prove hypothesis H2. ASEAN countries' greater banking assets (Size) will generally reduce banking efficiency.

The results of this study are in line with the findings by Batir et al. (2017), Isik & Hassan (2002), and Anh (2022), who found a negative relationship between the lnsize variable and cost efficiency in the Turkish banking system, but are in contrast to and Saha et al., (2015) and Nguyen (2018).

The regression results found that the value of lnROAA has no significant effect on banking efficiency. A bank's ROAA increase is generally not followed by a rise in banking efficiency. These findings are in line with research by Saha et al. (2015) and Nguyen (2018), who found that profitability has a significant and positive effect on cost efficiency but is in contrast to research by Ismail et al. (2013).

From the regression results, in terms of lnCapital value, it influences the value of banking efficiency. An increase in lnCapital at banks will reduce the value of bank efficiency. In other words, an increase in lnCapital of a bank will lead to a rise in banking efficiency. The results of this regression are consistent with the findings of Ismail et al. (2013), who found a negative and significant relationship between capital and cost efficiency. However, contrary to Batir et al. (2017), who found that the larger the bank's capital, the more efficient the bank is.

To proxy for a company's credit risk, the first variable used is the ratio of loans to assets (lnTLTA). This variable does not significantly affect efficiency in a negative relationship. The results of this regression are not in line with the findings of Anh (2022), which shows that a higher level of risk-taking has a lower efficiency level but follows the research of Ismail et al. (2013), which found the opposite result.

The second risk variable is lnLRGL, which divides the loan loss reserve by the gross loan. The regression results show that the lnLRGL variable significantly affects cost efficiency. An increase in lnLRGL for a bank causes a decrease in banking efficiency. We prove hypothesis H3. Decreasing banking credit risk (LRGL) in ASEAN countries will increase banking efficiency.

This finding aligns with the research results by Sapci & Miles (2019), which found a negative and significant relationship between the efficiency level and loan losses. Ismail et al. (2013) and Saha et al. (2015) also found that non-performing loans negatively and significantly affect banking efficiency.

Table 7. Score and ranking of banking efficiency for each country

No	Country	Efficiency score	Ranking
1	Indonesia	0.885597	3
2	Malaysia	0.872559	7
3	Vietnam	0.874134	6
4	Thailand	0.909756	1
5	Singapore	0.888637	2
6	Kamboja	0.877376	5
7	Brunei Darussalam	0.861755	9
8	Filipina	0.880986	4
9	Myanmar	0.868323	8
10	Laos	0.853406	10

Source: Data Processed, 2023

The last risk variable is lnLLPL, which is the division between the value of the loan loss provision and the total loan. From the regression results, it is known that lnLLPL has no significant effect on efficiency. Similar findings were also obtained by Mongid (2015) and (Pickens et al., 2009), who found no meaningful relationship between lnLLPL variables and efficiency.

Estimating equation (9) produces an efficiency score that can be grouped by country. The banking efficiency ranking of each country is described in Table 8.

Table 8. Score and ranking of banking efficiency for each year

Year	Average Score	Ranking
2012	0.871067	6
2013	0.874682	5
2014	0.874775	4
2015	0.876088	2
2016	0.876527	1
2017	0.875292	3

Source: Data Processed, 2023

Thailand, Singapore, and Indonesia have the highest levels of banking efficiency (Table 7). Some countries that have low efficiency scores are Laos, Brunei-Darussalam, and Myanmar. When viewed from the development of banking efficiency in Indonesia, it turns out that the efficiency trend is improving, where the highest banking cost efficiency occurred in 2017.

In addition to looking at macro indicators that affect the level of bank efficiency, the structure of bank ownership and competition between banks in each country can be tried to be added, as was done by (Berger et al., 2009) because the results of the study show that there are different levels of efficiency between banks with different ownership structures (foreign or domestic). Bank-specific determinants can also be added in subsequent studies in addition to the ROE used in this study.

Every company, including banks, must increase their efficiency to compete in the market, including if the market is expanded into the ASEAN region. In the previous few years, the ASEAN Banking Integration Forum (ABIF) began to agree on banking integration towards efficiency. Indonesia, represented by Bank Indonesia, approved the ASEAN Banking Integration Framework (ABIF). With the implementation of ABIF, it is hoped that banks and business players can develop their business more broadly, efficiently, and stably in the ASEAN region.

The main objective of ABIF is to provide market access and operational flexibility in ASEAN member countries for Qualified ASEAN Banks (QAB), namely ASEAN banks with certain conditions mutually agreed upon by ASEAN. Integration needs to standardize the system is the most challenging negotiation. Currently, there are around 120 banks of various classes. They must face much bigger Malaysian and Singaporean banks in the current global era.

Indonesia and several ASEAN countries have agreed to the MoU in the Bilateral Agreement between OJK and Bank Negara Malaysia. Indonesia faces opportunities and potential for banks and business players to expand into the ASEAN market. This opportunity is perfect for anticipating

developments in Indonesian finance and banking. Inclusive financial development policies and the development of FINTEC (Financial Technology) in banking are crucial to producing efficiency, and branchless banking is currently relevant. Branchless banking is a strategy for reducing overhead and connectivity costs (Pickens et al., 2009).

CONCLUSION

This study has analyzed the alleged influence of credit risk on banking efficiency in 10 ASEAN countries from 2012-2021. The result of this study is that there will be an increase in banking efficiency in ASEAN in 2021 compared to 2012. This study is in line with several related studies and indirectly shows that banks in ASEAN are increasingly preparing themselves for the ABIF policy in 2020.

Then this study can also see the relationship between credit risk and the value of banking efficiency. Based on the research results, there is a negative relationship between credit risk and efficiency. This result is probably caused by the increasing number of banks extending credit. The greater the credit risk the banks will bear. This risk can be in the form of losing the loan money or interest on the loan.

Furthermore, resolving default events also requires more costs, for example, the foreclosure of collateral and the auction process. This process causes credit risk, in general, to increase overall banking costs. The risk variable with the most significant influence on efficiency is the loan-to-asset ratio (TLTA) variable, where an increase in TLTA will reduce banking efficiency. This variable can be used as an instrument or indicator for policymakers to maintain banking efficiency in their respective countries.

Based on the findings above, it is deemed necessary for the government to improve control over risk due to the impact of credit risk on banking cost efficiency. Moreover, with the implementation of ABIF in 2020, where there will be many foreign banks that can operate within ASEAN countries. Of course, the higher the competition, the more likely banks will be willing to take risks on loans that have the potential to default.

REFERENCES

Ahmad, W., & Luo, R. H. (2010). Comparison of banking efficiency in Europe: Islamic versus conventional banks. *International Finance Review*, *11*, 361–389. https://doi.org/10.1108/S1569-3767(2010)0000011016

Altunbas, Y., Carbo, S., Gardener, E. P. M., & Molyneux, P. (2007). Examining the relationships between capital, risk, and efficiency in European banking. *European Financial Management*, *13*(1), 49–70. https://doi.org/10.1111/j.1468-036X.2006.00285.x

Altunbaş, Y., Gardener, E. P. M., Molyneux, P., & Moore, B. (2001). Efficiency in European banking. *European Economic Review*, *45*(10), 1931–1955. https://doi.org/10.1016/S0014-2921(00)00091-X

Altunbas, Y., Liu, M. H., Molyneux, P., & Seth, R. (2000). Efficiency and risk in Japanese banking. *Journal of Banking and Finance*, *24*(10), 1605–1628. https://doi.org/10.1016/S0378-4266(99)00095-3

Alzubaidi, H., Bougheas, S., Markets, C., Clive, S., & Building, G. (2012). *Working Paper 12/05*. *44*(0), 0–31.

Anginer, D., Demirguc-Kunt, A., & Zhu, M. (2014). How does competition affect bank systemic risk? *Journal of Financial Intermediation*, *23*(1), 1–26. https://doi.org/10.1016/j.jfi.2013.11.001

Anh, D. Van. (2022). Does better capitalization enhance bank efficiency and limit risk-taking? Evidence from ASEAN commercial banks. *Global Finance Journal*, *53*. https://doi.org/10.1016/j.gfj.2021.100617

Arif, U., & Ahmad, E. (2020). A framework for analyzing the impact of fiscal decentralization on macroeconomic performance, governance, and economic growth. *Singapore Economic Review*, *65*(1), 3–39. https://doi.org/10.1142/S0217590818500194

ARIFF, M., & CAN, L. (2008). Cost and profit efficiency of Chinese banks: A non-parametric analysis. *China Economic Review*, *19*(2), 260–273. https://doi.org/10.1016/j.chieco.2007.04.001

Batir, Eyceyurt, T., Volkman, D. A., & Gungor, B. (2017). Determinants of bank efficiency in Turkey: Participation banks versus conventional banks. *Borsa Istanbul Review*, *17*(2), 86–96. https://doi.org/10.1016/j.bir.2017.02.003

Berger, A. N., Klapper, L. F., & Turk-Ariss, R. (2009). Bank competition and financial stability. *Journal of Financial Services Research*, *35*(2), 99–118. https://doi.org/10.1007/s10693-008-0050-7

Carlson, M., Shan, H., & Warusawitharana, M. (2013). Capital ratios and bank lending: A matched bank approach. *Journal of Financial Intermediation*, *22*(4), 663–687.

https://doi.org/10.1016/j.jfi.2013.06.003

Chan, S. G., Koh, E. H. Y., & Kim, Y. C. (2016). Effect of Foreign Shareholdings and Originating Countries on Banking Sector Efficiency. *Emerging Markets Finance and Trade*, *52*(9), 2018–2042. https://doi.org/10.1080/1540496X.2016.1142231

Coelli, T., Rao, D. S. P., & Battese, G. E. (1998). An Introduction to Efficiency and Productivity Analysis. *An Introduction to Efficiency and Productivity Analysis*. https://doi.org/10.1007/978-1-4615-5493-6

Ekananda, M. (2016). *Analisis Ekonometrika Data Panel: Edisi Kedua* (Second). Mitra Wacana Media.

Fries, S., & Taci, A. (2005). Cost efficiency of banks in transition: Evidence from 289 banks in 15 post-communist countries. *Journal of Banking and Finance*, *29*(1 SPEC. ISS.), 55–81. https://doi.org/10.1016/j.jbankfin.2004.06.016

Gaganis, C., & Pasiouras, F. (2009). Efficiency in the Greek banking industry: A comparison of foreign and domestic banks. *International Journal of the Economics of Business*, *16*(2), 221–237. https://doi.org/10.1080/13571510902917533

Gardener, E., Molyneux, P., & Nguyen-Linh, H. (2011). Determinants of efficiency in South East Asian banking. *Service Industries Journal*, *31*(16), 2693–2719. https://doi.org/10.1080/02642069.2010.512659

Greene, W. (2010). *Econometric Analysis* (Seventh). Macmilan Publishing Company.

Grigorian, D. A., & Manole, V. (2006). Determinants of Commercial Bank Performance in Transition: An Application of Data Envelopment Analysis. *Comparative Economic Studies*, *48*(3), 497–522. https://doi.org/10.1057/palgrave.ces.8100129

Isik, I., & Hassan, M. K. (2002). Technical, scale and allocative efficiencies of the Turkish banking industry. *Journal of Banking and Finance*, *26*(4), 719–766. https://doi.org/10.1016/S0378-4266(01)00167-4

Ismail, F., Shabri Abd. Majid, M., & Rahim, R. A. (2013). Efficiency of Islamic and conventional banks in Malaysia. *Journal of Financial Reporting and Accounting*, *11*(1), 92–107. https://doi.org/10.1108/jfra-03-2013-0011

Kallio, M., & Hardoroudi, D., N. (2019). Advancements in stochastic dominance efficiency tests. *European Journal of Operational Research*, *276*(2), 790–794. https://doi.org/10.1016/j.ejor.2018.12.014

Kapuściński, M. (2017). The Role of Bank Balance Sheets in Monetary Policy Transmission: Evidence from Poland. *Eastern European Economics*, *55*(1), 50–69. https://doi.org/10.1080/00128775.2016.1255559

Karagiannis, G., & Kellermann, M. (2019). Stochastic frontier models with correlated effects. *Journal of Productivity Analysis*, *51*(2–3), 175–187. https://doi.org/10.1007/s11123-019-00551-y

Le, M., Hoang, V. N., Wilson, C., & Managi, S. (2020). Net stable funding ratio and profit efficiency of commercial banks in the US. *Economic Analysis and Policy*, *67*, 55–66. https://doi.org/10.1016/j.eap.2020.05.008

Marcelin, I., Egbendewe, A. Y. G., Oloufade, D. K., & Sun, W. (2022). Financial inclusion, bank ownership, and economy performance: Evidence from developing countries. *Finance Research Letters*, *46*. https://doi.org/10.1016/j.frl.2021.102322

Mataba, L., & Aikaeli, J. (2016). Empirical Analysis of Efficiency of Community Banks in Tanzania. *International Journal of Economics and Finance*, *8*(12), 77. https://doi.org/10.5539/ijef.v8n12

Maudos, J., Pastor, J. M., Pérez, F., & Quesada, J. (2002). Cost and profit efficiency in European banks. *Journal of International Financial Markets, Institutions and Money*, *12*(1), 33–58. https://doi.org/10.1016/S1042-4431(01)00051-8

Mongid, A. (2015). Cost efficiency of the ASEAN banking market. *International Business Management*, *9*(7), 1580–1586. https://doi.org/10.3923/ibm.2015.1580.1586

Nguyen, T. L. A. (2018). Diversification and bank efficiency in six ASEAN countries. *Global Finance Journal*, *37*, 57–78. https://doi.org/10.1016/j.gfj.2018.04.004

Ollivaud, P., & Turner, D. (2014). The effect of the global financial crisis on OECD potential output. *OECD Journal: Economic Studies*, *1*, 41–60. https://doi.org/10.1787/eco_studies-2014-5js64l2bv0zv

Pesaran, M. H., & Schmidt, P. (2008). Handbook of Applied Econometrics. *Handbook of Applied Econometrics*, *2*, 1–339. https://doi.org/10.1111/b.9780631216339.1999.x

Pickens, M., Porteous, D., & Rotman, S. (2009). Scenarios for Branchless Banking in 2020. *Scenario*, 1–27. http://www.cgap.org/gm/document-1.9.40599/FN57.pdf

Saha, A., Ahmad, N. H., & Dash, U. (2015). Drivers of technical efficiency in Malaysian banking: A new empirical insight. *Asian-Pacific Economic Literature*, *29*(1), 161–173. https://doi.org/10.1111/apel.12091

Sapci, A., & Miles, B. (2019). Bank size, returns to scale, and cost efficiency. *Journal of Economics and Business*, *105*. https://doi.org/10.1016/j.jeconbus.2019.04.003

Sari, R. P., Tjahjono, H., & Turino. (2018). Analysis of Financial Performance in Public Sector (A Case Study in Lamongan, East Java-Indonesia). *Journal of Accounting and Strategic Finance*, *1*(1), 82–90. https://doi.org/10.33005/jasf.v1i01.35

Tan, Y. (2016). Theory of Bank Efficiency and Bank Risk. *Investigating the Performance of Chinese Banks: Efficiency and Risk Features*, 53–77. https://doi.org/10.1057/978-1-137-49376-7_3

Ye, Q., Xu, Z., & Fang, D. (2012). Market structure, performance, and efficiency of the Chinese banking sector. *Economic Change and Restructuring*, *45*(4), 337–358. https://doi.org/10.1007/s10644-012-9123-6

Zhang, T., & Matthews, K. (2012). Efficiency convergence properties of Indonesian banks 1992-2007. *Applied Financial Economics*, *22*(17), 1465–1478. https://doi.org/10.1080/09603107.2012.663468

Zhao, C. H., & Xu, Y. Y. (2013). The determinants of shareholder value efficiency in Chinese commercial banks. *19th International Conference on Industrial Engineering and Engineering Management: Engineering Economics Management*, 237–243. https://doi.org/10.1007/978-3-642-38442-4_25.