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FINANCIAL INCLUSION AND BANK EFFICIENCY IN THE ASEAN 5+1 REGION: ACCESS, USAGE AND ECONOMIC PARTICIPATION

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Abstract:

Financial inclusion can broaden economic participation, but different access and usage channels may affect bank efficiency in different ways. This study examines the relationship between financial inclusion and bank efficiency across 200 commercial banks in six ASEAN economies: Indonesia, Malaysia, Singapore, Thailand, the Philippines, and Vietnam over the period 2013-2021 using an unbalanced panel of 1,500 usable bank-year observations. Bank efficiency is estimated using Data Envelopment Analysis (DEA) under constant and variable returns to scale, while the relationships between nine financial inclusion indicators and technical efficiency are examined using pooled ordinary least squares and bank fixed-effects models with robust standard errors. The findings reveal substantial cross-country differences in bank efficiency, with Thailand recording the highest average technical efficiency and the Philippines the lowest. Among the financial inclusion indicators, ATMs per 100,000 adults, credit cards, debit cards, and outstanding loans are positively associated with bank efficiency, whereas geographical ATM density, branch density, bank accounts, and outstanding deposits show negative associations. These results indicate that financial inclusion does not affect bank efficiency uniformly and

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that the operational effects depend on the specific channel through which access and usage are expanded. By analysing individual indicators rather than a composite financial inclusion index, this study provides more detailed evidence on how different dimensions of financial inclusion are associated with bank efficiency across heterogeneous ASEAN banking systems during the pre-pandemic and initial COVID-19 period.

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Keyword:

ASEAN 5+1, Bank Efficiency, COVID-19, Data Envelopment Analysis, Financial Inclusion

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Introduction

The financial inclusion element has emerged as a key area for economic participation and social resilience in ASEAN. However, the availability of formal financial services is still inadequate in some parts of the region. Variations in branch coverage, access to automated teller machines, account ownership, payment-card use, deposits, and access to credit remain important factors in determining the extent of household and firm involvement in the formal economy. These disparities are also relevant to banks as it impacts the banks' risk profile, transaction volume, delivery costs, and customer base with expansion of access. Financial inclusion and bank efficiency are not necessarily tied together. More customers mean more deposits, transactions and lending opportunities, which means that banks can share fixed costs across more customers. Gaining access to low-balance, dispersed and previously unserved customers may also require more investment in technology, compliance, employee training, consumer protection, and in physical service points. Financial inclusion can contribute to efficiency gains via scale and revenue effects or efficiency losses if the costs of implementation and servicing exceed the costs of productive use.

This study concentrates on Indonesia, Malaysia, Singapore, Thailand, Philippines and Vietnam. ASEAN 5+1 is an expression of the five initial economies of ASEAN and the one added economy, Vietnam. Vietnam has been included for its rapid expansion and deepening of the banking sector as an important example to compare with the more advanced banking systems in the group. The six banking systems together make up a significant portion of banking activity in the ASEAN region, and they exhibit a very different level of income, financial development, institutional capacity and readiness to digitalize. There is inconclusive evidence from previous studies. Others believe that financial inclusion in banking helps to improve bank performance or stability by expanding funding sources, diversifying customers and improving bank lending practices (Ahamed et al., 2021; Nguyen & Du, 2022). Others demonstrate that the impact varies

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based on the delivery system, institutional context and level of adoption. For instance, in Malaysia, Singapore, and Thailand, credit and charge-card transactions lead to higher gains in certain bank performance indicators, while other electronic payment methods do not achieve such results (Lu, et al., 2022). Moreover, Ha and Nguyen (2023) demonstrate that the influence of financial inclusion on bank stability varies depending on institutional quality in ASEAN. Other more contemporary evidence also indicates that there are threshold and nonlinear effects, not a consistent positive relationship (Dang, 2025; Khan et al., 2024).

Three gaps motivate this study. First, much of the literature combines several financial inclusion measures into a composite index, which can conceal opposing effects across individual indicators. Second, studies often focus on a single country or a limited set of banking outcomes, making it difficult to compare banks operating under different economic and institutional conditions. Third, relatively little evidence connects disaggregated financial inclusion indicators with bank efficiency across ASEAN during a period that includes the COVID-19 shock. Accordingly, the study has three objectives. First, it estimates and compares technical efficiency, pure technical efficiency, and scale efficiency across the six banking sectors. Second, it examines the individual relationships between accessibility and usage indicators and bank efficiency. Third, it evaluates whether the patterns differ across country income groups and remain stable under alternative efficiency and panel specifications. The study contributes in three ways. It provides a disaggregated assessment of nine financial inclusion indicators rather than relying on a single index. It compares 200 commercial banks across six heterogeneous ASEAN economies using a common intermediation framework. It also treats 2013-2021 as a clearly bounded analytical period, combining a seven-year pre-pandemic benchmark with the immediate COVID-19 disruption and early institutional adjustment. The paper does not claim that the period represents the later post-pandemic digital-finance environment.

Literature Review

Why Financial Inclusion Shapes Bank Behaviour: Three Social and Institutional Channels

Measures of financial inclusion can affect financial institution efficiency in three related ways: via financial intermediation, via institutional adaptation, and via broader social benefits. These channels may or may not flow in the same direction. More access can lead to more funding and more customers for banks, but can also mean more costs for operating the business and complying with the law. The net effect will depend on the quality of service provided, on the extent of active customer use and on the effectiveness of banks in translating increased access into intermediate services that can stimulate economic activity. The first channel is purely financial. Diamond (1984) provides an account of why banks can lower the cost of linking savers and borrowers by screening and monitoring credit relationships. In this view, expanding the deposit base, increasing the number of borrowers, and expanding transactions via increased participation from individuals and firms in the formal financial sector can enlarge the deposit base, broaden the borrower base, and expand transactions. These shifts can reduce average costs as the fixed costs are distributed among more borrowers and excess resources are redirected towards productive loans and investment.

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Contrasting evidence from the ASEAN region in recent times suggests this mechanism in general, but not always. For the six ASEAN countries, Nguyen and Du (2022) conclude that increased financial inclusion is linked to more stable deposit funding and reduced non-performing loan ratios. But, simply being there does not mean they perform better. In Malaysia, Singapore, and Thailand, credit- and charge-card transactions positively affect the operating income and return on equity, whereas other transactions such as e-money, debit-card, internet-banking, and mobile-banking transactions do not similarly provide statistically significant benefits, as shown by Lu et al. (2022). The stark contrast implies that the intensity of the transactions, revenues generated, and the expense of retaining each channel are just as important as the fact that services are available.

The second channel is the institutional adaptation. North (1990) argued that institutions influence the behavior of an organization through their rules, policies, and expectations. Plans and strategies for financial inclusion may involve banks in investing in technology, reengineering services, creating consumer protection systems, developing data infrastructure, and training personnel to provide services to customers with varying financial needs. These changes can initially impact efficiency due to upfront costs and the gradual uptake of these changes by customers and the subsequent impact on revenue. Recent research is revealing the reasons why adaptation cannot be expected to bring immediate benefits. Khan et al. (2024) find a U-shaped relationship between fintech integration and bank efficiency in developing countries – at first, there is deterioration in efficiency, but further integration leads to efficiency improvements. Similarly, Chowdhury et al. (2024) emphasize the value of investing in technology for technical efficiency in Asian banking but also stress that this value is dependent on the level of maturity of the technology. For ASEAN, Ha and Nguyen (2023) report that financial inclusion has a negative stability impact, which is alleviated by higher institutional quality. In these studies, a transition process is indicated, where the ability to regulate, technology, and organisational learning are decisive as to whether or not the inclusion process becomes efficiency-enhancing.

The third channel is the social value of financial inclusion. Making more savings, payments and credit available can decrease the need for informal finance, strengthen household resilience and facilitate the involvement of small businesses. But some of these benefits flow to society not directly to the bank that has to pay the costs of implementation. While fintech can help increase inclusion in Southeast Asia, digital infrastructure, financial literacy, consumer protection, and regulatory readiness will be essential for the gains to materialise, notes Morgan (2022). Additionally, Ong et al. (2023) reveal that financial inclusion can be fostered through digitalisation in the lower-middle income ASEAN countries, with varying degrees of achievement by country. An inclusion programme can thus be socially desirable even if the impact of the programme on the short-run efficiency of the bank is small. Taken together, the three channels imply an ambiguous relationship between financial inclusion and bank efficiency. Inclusion can lead to efficiency gains in terms of deposit mobilisation, transaction growth, revenue diversification and scale economies. It can make it less efficient if the costs of infrastructure, technology, regulatory requirements and customer service are higher than the revenue of the new customers added to the business. This ambiguity encourages an individual analysis of the respective access and use indicators instead of their combination into a single index.

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Empirical Evidence on Bank Efficiency in ASEAN

Despite its many drawbacks, Data Envelopment Analysis is still one of the leading techniques employed in assessing bank efficiency since it does not involve a prior estimate of a functional form and can disentangle managerial efficiency from scale efficiency. The method is especially relevant in ASEAN where banks vary widely in size and market structure, ownership, and regulatory development. Some methodological studies however have recently highlighted the fact that the conclusions for DEA are still sensitive to the definition of the frontier, the selection of variables and extreme observation (Akdeniz et al., 2024).

There are significant differences in efficiency reported about in ASEAN studies. Previous studies typically link efficiency with profitability, capital strength, asset quality and/or operating costs, but the relationships vary in direction and magnitude between countries and time (Sufian & Habibullah, 2010; Kamarudin et al., 2017; Le et al., 2019). Alexakis et al. (2019) found that loan quality and income diversification are significant factors influencing bank performance, and recent studies by Chowdhury et al. (2024) associated fintech adoption with changes in technical efficiency among banks in Asia. These results indicate that bank efficiency is related to both internal management as well as the financial environment.

This study is an extension of the literature discussed above and compares commercial banks in six economies in the ASEAN, including both developed and underdeveloped economies. It employs the intermediation approach, as all the sampled institutions convert deposits, labour and physical capital into loans, investments and income. The common framework facilitates the comparison of countries and the decomposition of the technical, purely technical, and scale efficiency components allows for the separation between managerial performance and the operating scale issues.

Financial Inclusion and Bank Efficiency: Mixed and Conditional Evidence

The empirical link between financial inclusion and bank efficiency is not yet clear. Positive results typically highlight improved funding size and security, increased capacity to lend and reduced transaction costs. When regulation is conducive to effective intermediation, inclusive banking can enhance bank performance, as found by Ahamed et al. (2021). Likewise, Nguyen and Du (2022) find that financial inclusion contributes to the bank stability in the ASEAN in terms of several dimensions. Digital channels can also help reduce the cost of everyday transactions and expand access without the need for a comprehensive physical branch network (Morgan, 2022; Ong et al., 2023).

Other studies also look at costs, thresholds, as well as differential impacts. Dang (2025), however, shows that financial inclusion may lead to banks being less stable than usual if it is not highly developed, and more stable than usual if it is highly developed. In ASEAN, there is a moderating effect between the two relationships by institutional quality as demonstrated by Ha and Nguyen (2023). According to Lu et al. (2022) only some electronic payment services yield distinct performance benefits. In addition, Khan et al. (2024) demonstrate that the use of fintech could also decrease efficiency in the beginning but eventually achieve gains as integration improves. The conflicting results suggest that inclusion is not a uniform intervention, and that, and that its impact is scale, use, technology and institutional capacity dependent.

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The distinction between access and usage is therefore central. More branches, automated teller machines, or accounts may reduce physical and administrative barriers, but they also create fixed and recurring costs. Usage indicators capture whether customers transact, borrow, save, and make payments through the formal system. Even here, the effect is conditional. Deposits contribute to efficiency only when banks can deploy them productively, and lending contributes positively only when credit quality is maintained. The literature therefore supports a disaggregated empirical design that allows different indicators to produce different coefficients. The literature leaves two questions open. First, which individual access and usage indicators are associated with higher or lower bank efficiency in ASEAN? Second, do those relationships remain similar across banking systems with different levels of income and financial development? The following analysis addresses these questions using bank-level efficiency estimates and country-level financial inclusion indicators.

Research Design

Sample Construction, Scope, and Data Sources

The sample comprises 200 commercial banks from Indonesia (81), Malaysia (27), Thailand (26), Vietnam (43), the Philippines (18), and Singapore (5), observed annually from 2013 to 2021. The panel is unbalanced: the theoretical maximum is 1,800 bank-year observations, while 1,500 observations remain after listwise deletion for missing bank-level, financial-inclusion, or macroeconomic data. No interpolation or statistical imputation is applied. A bank contributes to a given annual frontier and regression only when the variables required for that observation are available. Bank-level financial data are obtained from Fitch Connect, financial inclusion indicators from the International Monetary Fund's Financial Access Survey, and macroeconomic controls from the World Bank's World Development Indicators.

Commercial banks are selected to preserve comparability across decision-making units. These institutions perform broadly similar functions by mobilising deposits and transforming financial, labour, and physical resources into loans, investments, and income. Development banks, microfinance institutions, cooperative institutions, and specialised financial providers operate under different mandates, funding structures, and regulatory requirements. Including them in the same frontier could weaken the assumption that all decision-making units use a comparable production technology. The findings should therefore be generalised primarily to commercial banks.

The country distribution reflects differences in banking-sector size, market structure, and data availability. Indonesia and Vietnam contribute more observations because they contain larger numbers of commercial banks, whereas Singapore contributes only five institutions. The common-frontier design is retained because all sampled decision-making units are commercial banks performing the same core intermediation function and are measured using an identical input-output set. This design enables direct comparison of relative efficiency across the six banking systems. At the same time, it imposes a strong comparability assumption: banks operating under different regulatory, technological, and financial-market conditions are treated as facing a sufficiently similar production technology to be evaluated against the same annual best-practice set. Countries with more banks can therefore exert greater influence on the frontier, and the Singaporean averages are based on a particularly small number of institutions. The variable-returns-to-scale specification reduces the influence of scale differences but does

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not eliminate structural heterogeneity. Country-specific or metafrontier estimates are therefore treated as an important robustness extension rather than as results already established by the present analysis.

Table 1: Sample Distribution by Country

Country	Number of banks
Philippines	18
Thailand	26
Indonesia	81
Singapore	5
Malaysia	27
Vietnam	43
Total	200

Note: Data are drawn from the Fitch Connect database.

The study period is intentionally bounded from 2013 to 2021. It provides a seven-year pre-pandemic benchmark (2013-2019) and captures the immediate COVID-19 disruption and early institutional adjustment in 2020-2021. The analysis is therefore designed to examine how conventional bank-based financial inclusion was related to bank efficiency before and during the initial pandemic shock. It is not presented as an estimate of the later post-pandemic banking environment. The endpoint is also relevant to the measurement strategy. The financial inclusion indicators used in this study primarily capture conventional bank-based access and usage through branches, automated teller machines, accounts, cards, deposits, and loans. After 2021, mobile platforms, digital-only banks, agent networks, and non-bank providers became increasingly central to financial access. Extending the series without adding comparable measures of these channels would risk combining two different service-delivery regimes while continuing to measure inclusion mainly through conventional banking indicators.

For this reason, the results are interpreted as period-specific evidence on the relationship between conventional financial inclusion and commercial-bank efficiency before and during the initial COVID-19 adjustment. The bounded design strengthens internal comparability across bank-level variables, financial inclusion indicators, and macroeconomic controls. A post-2021 extension remains valuable, but it would require a broader digital-finance construct and is treated as a separate research design rather than a simple addition of years.

Stage 1: Estimating Bank Efficiency through Data Envelopment Analysis

Bank efficiency is estimated using the intermediation approach developed by Sealey and Lindley (1977). Banks are modelled as intermediaries that transform deposits, labour, and physical capital into loans, investments, and income. The three inputs are total deposits and short-term funding, personnel expenses as a proxy for labour, and the book value of fixed assets as a proxy for physical capital. The outputs are total loans, total securities and investments, and net interest income. All monetary inputs and outputs are expressed in United States dollars and are strictly positive in the final estimation sample. No winsorisation, trimming, or super-

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efficiency outlier correction was applied in the original analysis. Because DEA is sensitive to extreme observations, this choice is made explicit and is considered when interpreting the results.

Both the constant-returns-to-scale (CRS) model of Charnes et al. (1978) and the variable-returns-to-scale (VRS) model of Banker et al. (1984) are employed. The efficiency frontier is constructed separately for each year using the commercial banks observed in that year, with banks from all six countries evaluated against a common annual frontier. This avoids forcing observations from 2013 and 2021 onto a single intertemporal frontier while still permitting cross-country comparison within each year. The CRS model produces overall technical efficiency (TE), whereas the VRS model produces pure technical efficiency (PTE). Scale efficiency is calculated as SE = TE_CRS / TE_VRS, so that overall technical efficiency can be decomposed into managerial and scale components.

The annual cross-sections satisfy the usual DEA dimensionality condition. With up to 200 decision-making units and three inputs and three outputs, the number of banks is well above both the product of inputs and outputs (9) and three times their sum (18). For bank o, the input-oriented VRS/BCC model is written as:

Minimise θ, subject to $Y\lambda \geq y_o$; $X\lambda \leq \theta x_o$; $e'\lambda = 1$; $\lambda \geq 0$.

Here, θ is the radial input-efficiency score, X and Y are the input and output matrices for the banks in the relevant year, x_o and y_o are the input and output vectors of the bank being evaluated, λ is the intensity vector, and $e'\lambda = 1$ imposes the VRS convexity restriction. The corresponding CRS model omits the convexity restriction. A score of one identifies a bank on the best-practice frontier; a score below one indicates the proportional reduction in inputs that would be feasible, relative to observed peers, while maintaining the same output vector. This formulation is consistent with the interpretation of an input-oriented BCC model and replaces the inconsistent formulation in the earlier manuscript.

Stage 2: Panel Regression Framework

The estimated DEA efficiency scores are used as the dependent variable in the second-stage analysis. Pooled ordinary least squares (OLS) provide the baseline estimates, while bank fixed effects control for time-invariant bank-specific heterogeneity. The Breusch-Pagan Lagrangian Multiplier test assesses whether panel heterogeneity is present, and the Hausman test guides the choice between fixed and random effects. Because the DEA score is bounded and generated in the first stage, the second-stage estimates are interpreted as conditional associations rather than structural causal effects. Following Banker and Natarajan (2008) and McDonald (2009), the original thesis uses OLS-based second-stage models rather than a conventional Tobit treatment of DEA scores. Technical efficiency is transformed to ln(TE), and White heteroskedasticity-consistent standard errors are reported in the original estimates.

An important feature of the data is that the financial inclusion indicators vary at the country-year level and are repeated for every bank observed in the same country and year. Consequently, the nominal total of 1,500 bank-year observations does not imply 1,500 independent observations for the main financial inclusion regressors. White heteroskedasticity-consistent standard errors address heteroskedasticity but do not fully account for within-

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country-year dependence. The reported significance levels should therefore be interpreted cautiously. A stronger inference procedure would cluster standard errors at the country-year level, use multi-way clustering, or apply an alternative two-stage DEA procedure such as Simar-Wilson bootstrapping. These extensions were not part of the original estimation and should be treated as additional robustness analyses rather than being implied by the present results.

The 2013-2021 period also contains common shocks, most notably the COVID-19 disruption in 2020-2021. The reported bank fixed-effects specifications do not separately include a full set of year dummies. Macroeconomic controls absorb part of the common time variation, but they may not capture all year-specific shocks. For this reason, a bank fixed-effects specification with year fixed effects, or another treatment of common temporal shocks, is a desirable robustness check before final resubmission. Until such a re-estimation is completed, the fixed-effects findings should not be presented as fully purged of common time effects.

The general model is specified as:

$$\ln(TE_{it}) = \alpha + \beta_1 BSC_{it} + \beta_2 MCc_t + \beta_3 FIDc_t + \mu_i + \varepsilon_{it}$$

where I denotes banks, c denotes countries, and t denotes years. BSC is a vector of bank-specific characteristics, MC contains country-year macroeconomic conditions, FID is the country-year financial inclusion indicator or set of indicators included in a given model, μ_i denotes bank fixed effects where applicable, and ε_{it} is the error term. The financial inclusion measures are separated across models to reduce multicollinearity and preserve their individual interpretation. Variance inflation factors remain below five across the reported specifications. A preferred robustness specification would additionally include year effects (λ_t), yielding $\ln(TE_{it}) = \alpha + \beta_1 BSC_{it} + \beta_2 MCc_t + \beta_3 FIDc_t + \mu_i + \lambda_t + \varepsilon_{it}$; however, coefficients from that specification are not reported here because the original dataset has not been re-estimated for this revision draft.

Table 2: Variable Definitions, Expected Signs, and Data Sources

Variable	Measurement	Expected sign	Data source
Dependent variable			
Technical efficiency (TE)	DEA score (VRS/BCC model)	–	Fitch Connect
Accessibility dimension			
ATMs per 100,000 adults	ATM_ADULTS	+	IMF FAS
ATMs per 1,000 km²	ATM_KM2	–	IMF FAS
Bank branches per 100,000 adults	BRANCH_ADULTS	–	IMF FAS
Bank branches per 1,000 km²	BRANCH_KM2	–	IMF FAS
Bank accounts per 1,000 adults	BANK_ACC	–	IMF FAS

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Variable	Measurement	Expected sign	Data source
Usage dimension			
Outstanding loans	OUT_LOAN	+	IMF FAS
Outstanding deposits	OUT_DEPO	–	IMF FAS
Number of credit cards	CRE_CARD	+	IMF FAS
Number of debit cards	DEB_CARD	+	IMF FAS
Bank-specific controls			
Credit risk	Loan loss reserve / total loans (LLR/TL)	–	Fitch Connect
Profitability	Return on assets (ROA)	+	Fitch Connect
Income diversification	Non-interest income / total assets (NII/TA)	+	Fitch Connect
Operating cost	Non-interest expenses / total assets (NIE/TA)	–	Fitch Connect
Capitalisation	Equity / total assets (EQASS)	+	Fitch Connect
Bank size	Natural log of total assets (TA)	+/–	Fitch Connect
Liquidity	Loans / total assets (LOANS/TA)	+	Fitch Connect
Macroeconomic controls			
GDP growth	ln(Real GDP growth rate)	+	World Bank WDI
Inflation	ln(CPI rate)	+/–	World Bank WDI
Market concentration	Three-bank asset share (CR3)	+/–	World Bank WDI
Unemployment rate	Unemployment rate (%)	–	World Bank WDI

Note: FAS = Financial Access Survey; WDI = World Development Indicators. Bank-specific ratio variables are expressed in natural logarithms in the regression models. Financial-inclusion variables retain the country-year units reported in the underlying IMF FAS series and are matched to every bank observed in the corresponding country and year. Because several usage indicators are labelled compactly in the source dataset, the final submitted version should reproduce the exact IMF FAS unit for OUT_LOAN, OUT_DEPO, CRE_CARD, and DEB_CARD to avoid ambiguity.

Analysis And Discussion

Descriptive Overview

Table 3 summarises the regression variables. The mean of logged technical efficiency is -0.683, which corresponds to an average efficiency of approximately 0.505 in levels. The dispersion is

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substantial, indicating that banks differ meaningfully in how effectively they transform inputs into outputs. The financial inclusion indicators also vary widely across the six countries. Automated teller machines per 100,000 adults range from 2.10 to 207.60, while branches per 100,000 adults range from 1.20 to 28.60. This variation reflects genuine differences in geography, financial development, and service-delivery models. It provides useful identifying variation, but it also reinforces the need to interpret pooled coefficients as average relationships across heterogeneous banking systems.

Table 3: Descriptive Statistics

Variable	Mean	Std. Dev.	Minimum	Maximum
ln(TE)	-0.683	0.521	-2.813	0.000
ATM_ADULTS	62.14	46.87	2.10	207.60
ATM_KM2	34.72	51.23	0.20	195.40
BRANCH_ADULTS	9.43	5.61	1.20	28.60
BRANCH_KM2	6.87	9.24	0.10	42.70
BANK_ACC	842.31	415.62	110.40	2,148.50
OUT_LOAN	53.28	28.41	12.60	143.20
OUT_DEPO	88.47	41.63	22.30	218.90
CRE_CARD	0.142	0.218	0.001	0.924
DEB_CARD	0.748	0.592	0.024	3.271
ln(LLR/TL)	-3.412	1.024	-8.610	1.329
ln(ROA)	-1.628	0.874	-7.214	1.098
ln(NII/TA)	-3.714	0.961	-7.823	0.214
ln(NIE/TA)	-2.891	0.764	-6.427	0.412
ln(EQASS)	-2.317	0.812	-5.621	0.683
ln(TA)	13.812	1.624	9.241	21.087
ln(LOANS/TA)	-0.742	0.418	-2.814	0.218
ln(INF)	1.214	0.874	-1.427	3.618
ln(CR3)	3.847	0.641	2.614	5.124
ln(UNEMP)	1.618	0.529	0.214	3.247

Note: The sample consists of 200 banks from six ASEAN economies during 2013–2021. N = 1,500 after listwise deletion. Financial inclusion indicators are country-level variables matched to each bank-year observation.

Bank Efficiency across ASEAN 5+1

There are clear differences in bank efficiency between the six countries as illustrated in Table 4. Thailand and Malaysia have the top two average technical efficiency values in the region of 0.599 and 0.587, respectively. With a score of 0.348, the Philippines has the lowest average, followed by Indonesia with 0.395. The results show that the output resulting from the resources observed varies widely across the region. Vietnam is different. The average technical efficiency is 0.452 while the maximum technical efficiency is the Pure Technical Efficiency that is 0.795

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in the sample. From a managerial point of view, the available resource utilization is relatively good, while from a scale point of view, the Vietnamese banks are operating away from the optimum. This is confirmed by the low mean scale efficiency of 0.597. Rapid expansion could have driven increases in output, but scale of operations was not necessarily growing equally quickly as governance, risk management, and market depth.

The average TE for Singapore is 0.525, lower than the averages for Malaysia (0.544) and Thailand (0.600). This does not mean that Singapore's banking system is less developed. DEA compares the transformation of a set of selected inputs to a set of selected outputs against the observed frontier. The measured score could be influenced by sophisticated regulation, complex business models, high compliance costs and activities not fully captured by the selected outputs. In addition, there is a small sample size in Singapore. Efficiency decreased in 2020 in many countries in the sample, but the magnitude of the decrease varied by country. The pattern follows the same as the current operational and economic disruption due to COVID-19. In 2021, Malaysia, Thailand, Singapore and Vietnam recovered to some degree, while Indonesia and the Philippines lagged behind their 2019 levels. The outcome suggests that 2020-2021 should be interpreted as a first shock and adaptation phase rather than a period of stabilization and recovery after the pandemic.

Table 4: DEA Efficiency Scores for ASEAN 5+1 Banking Sectors, 2013–2021

Year	Malaysia	Thailand	Singapore	Vietnam	Indonesia	Philippines
Panel A: Technical Efficiency (TE)						
2013	0.512	0.517	0.523	0.434	0.389	0.341
2014	0.498	0.486	0.512	0.435	0.381	0.337
2015	0.515	0.551	0.423	0.346	0.344	0.265
2016	0.545	0.582	0.409	0.404	0.332	0.271
2017	0.669	0.674	0.607	0.476	0.454	0.414
2018	0.657	0.688	0.615	0.426	0.407	0.374
2019	0.621	0.666	0.455	0.537	0.459	0.391
2020	0.609	0.629	0.578	0.501	0.413	0.378
2021	0.655	0.625	0.603	0.544	0.380	0.352
Mean	0.587	0.599	0.525	0.452	0.395	0.348
Panel B: Pure Technical Efficiency (PTE)						
2013	0.579	0.603	0.603	0.737	0.520	0.203
2014	0.531	0.535	0.563	0.782	0.495	0.397
2015	0.598	0.676	0.513	0.765	0.515	0.435
2016	0.599	0.682	0.485	0.819	0.513	0.396
2017	0.693	0.706	0.631	0.764	0.584	0.468
2018	0.688	0.734	0.649	0.772	0.557	0.438
2019	0.705	0.694	0.581	0.828	0.567	0.413
2020	0.692	0.724	0.664	0.875	0.666	0.473

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Year	Malaysia	Thailand	Singapore	Vietnam	Indonesia	Philippines
2021	0.711	0.680	0.692	0.874	0.642	0.445
Mean	0.644	0.682	0.598	0.795	0.562	0.408
Panel C: Scale Efficiency (SE)						
2013	0.888	0.841	0.865	0.630	0.799	0.217
2014	0.932	0.908	0.895	0.595	0.844	0.859
2015	0.868	0.785	0.815	0.489	0.722	0.642
2016	0.904	0.818	0.822	0.509	0.702	0.732
2017	0.968	0.946	0.958	0.674	0.825	0.918
2018	0.959	0.927	0.933	0.598	0.762	0.909
2019	0.892	0.958	0.869	0.678	0.853	0.961
2020	0.888	0.837	0.845	0.570	0.631	0.829
2021	0.919	0.899	0.848	0.613	0.599	0.829
Mean	0.913	0.867	0.872	0.597	0.749	0.766

Note: TE = technical efficiency; PTE = pure technical efficiency; SE = scale efficiency. Scores range from zero to one. Source: Authors' calculations using Fitch Connect data.

Financial Inclusion and Bank Efficiency

Tables 5A and 5B present the main financial inclusion coefficients, while Appendix Table A1 reports the control variables and diagnostic statistics. Models 1-3 use pooled OLS and Models 4-5 use bank fixed effects. The Breusch-Pagan Lagrangian Multiplier statistics indicate panel heterogeneity, and the Hausman statistics favour fixed effects over random effects for the corresponding specifications. Because the financial inclusion regressors are measured at the country-year level and repeated across banks, the coefficients are interpreted as conditional associations between country-level inclusion conditions and bank-level efficiency, not as bank-specific causal effects. The reported heteroskedasticity-robust standard errors should also be read in light of the dependence issue described in the methodology section.

Table 5A: Accessibility Indicators and Bank Efficiency

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
ATM_ADULTS	0.024***			0.019**	
	(0.006)			(0.008)	
ATM_KM2		-0.018**			-0.014*
		(0.007)			(0.008)
BRANCH_ADULTS			-0.031***		
			(0.009)		
BRANCH_KM2			-0.026**		
			(0.010)		
BANK_ACC			-0.008**		
			(0.004)		

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Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Estimator	Pooled OLS	Pooled OLS	Pooled OLS	Fixed effects	Fixed effects

Note: The dependent variable is ln(TE). Robust standard errors are shown in parentheses. Model 3 reports branch and account indicators jointly. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

Table 5B: Usage Indicators and Bank Efficiency

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
CRE_CARD	0.041*** (0.012)	0.039*** (0.012)	0.038*** (0.012)	0.034** (0.015)	0.032** (0.015)
DEB_CARD	0.028** (0.013)	0.027** (0.013)	0.026** (0.013)	0.022* (0.012)	0.021* (0.012)
OUT_LOAN	0.047*** (0.011)	0.045*** (0.011)	0.044*** (0.011)	0.039*** (0.013)	0.037*** (0.013)
OUT_DEPO	-0.032*** (0.009)	-0.030*** (0.009)	-0.029*** (0.009)	-0.025*** (0.009)	-0.023*** (0.009)
Bank controls	Yes	Yes	Yes	Yes	Yes
Macroeconomic controls	Yes	Yes	Yes	Yes	Yes
Observations	1,500	1,500	1,500	1,500	1,500

Note: The dependent variable is ln(TE). Robust standard errors are shown in parentheses. Full control-variable estimates and diagnostics are reported in Appendix Table A1. ***, **, and * denote significance at the 1%, 5%, and 10% levels.

Accessibility Dimension

Automated teller machines per 100,000 adults are positively associated with bank efficiency in both the pooled and fixed-effects specifications. Because the dependent variable is ln(TE), coefficients on inclusion measures that enter in levels are semi-elasticities: the sign indicates whether higher country-level access is associated with higher or lower bank efficiency, while the coefficient magnitude reflects the percentage change in TE associated with a one-unit change in the relevant indicator, subject to the indicator's measurement scale. The result is consistent with the view that technology-assisted service points can shift routine transactions away from labour-intensive counters and allow existing staff and capital to serve more customers. The coefficient should not be interpreted as evidence that every additional machine mechanically raises efficiency; it is an average association within the study period and model specification. Automated teller machines per 1,000 square kilometres show a negative relationship, which may reflect diminishing returns where machines are densely concentrated relative to transaction demand.

There are negative relationships between efficiency and both branch-density measures. Physical branches include a higher cost of premises, staff, security and administration, which are usually higher than the cost of typical digital transactions. This does not mean that branches aren't needed. Face-to-face services may still be needed in rural areas, with older users or those who do not use digital services. The finding instead is used to support models of targeted branch

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provision and sharing models or agent-based models rather than uniform network expansion. Negative coefficient is also found in bank accounts per 1000 adults. The caveat for this finding is that it needs to be taken with a grain of salt. It does not imply that it is bad to know how to have an account, or that it decreases efficiency to open accounts directly. The coefficient could also include inactive or low-balance accounts that represent transaction and lending volume with no associated maintenance, compliance or monitoring costs. Since activity in the accounts is not tracked directly, it is possible that they were dormant or used sparingly but not as a mechanism.

Usage Dimension

The usage indicators show a more positive trend. The results indicate that credit-card penetration is positively related to efficiency in all of the specifications. Cards can bring in fee and interest income, minimise cash handling and give credit assessment information. This finding aligns with the Southeast Asian study by Lu et al. (2022) which indicates that credit and charge cards do better than several other electronic payment channels. The estimated effect of debit card use is also positive, but smaller, and is related to efficiency. Debit cards are not used for payment processing and do not earn interest income, but primarily for lower-cost payment processing and to replace the need for cash. Their contribution will therefore be likely to come from transaction efficiency and customer engagement.

The efficiency is positively related to outstanding loans. Origination, monitoring and compliance costs can be distributed among a wider base of customers, and there's an interest income to be gained from a larger performing loan portfolio. This interpretation will be subject to credit quality interpretation. Not all loan growth that leads to future NPLs would necessarily result in higher efficiency; hence the regressions also control for credit-risk. The negative association with efficiency for outstanding deposits is excellent. The coefficient does not mean mobilisation of deposits is inefficient in itself. Instead, it proposes that the growth in deposits does not necessarily correspond to the growth of productive lending or investment. A number of factors can undermine the short-term efficiency edge, including excess liquidity, sluggish loan demand, regulatory liquidity holdings, and the servicing cost of low-balance deposits. These models are not directly linked to each additional deposit, so they can only be considered as tentative economic interpretations, not explanations.

Bank-Specific and Macroeconomic Determinants

Operating cost is the largest bank-specific determinant in absolute terms. The coefficient on non-interest expenses to total assets is consistently negative and highly significant, indicating that cost control is central to the conversion of resources into banking outputs. Income diversification and profitability are positively associated with efficiency, while stronger capitalisation also has a positive relationship. These results are consistent with the view that profitable and well-capitalised banks have greater flexibility to invest, absorb shocks, and spread fixed costs. Bank size carries a negative coefficient. This finding runs against a simple economies-of-scale argument and suggests that larger banks may face bureaucratic complexity, legacy infrastructure, and heavier compliance requirements. The positive coefficient on loans to total assets indicates that active intermediation is more closely associated with efficiency than size alone.

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Among the macroeconomic controls, GDP growth is positive and unemployment is negative. Stronger economic conditions support credit demand, fee income, and asset quality, while higher unemployment weakens household and business repayment capacity. Market concentration is positively associated with efficiency, although the coefficient can be consistent with both market-power and efficient-structure explanations. Inflation is not statistically significant in the reported models.

Robustness Checks

The robustness and diagnostic procedures completed in the original thesis address estimator selection, distributional differences, subgroup heterogeneity, and multicollinearity. Pooled OLS with White heteroskedasticity-consistent standard errors is complemented by fixed- or random-effects estimation; the Breusch-Pagan Lagrangian Multiplier test assesses whether panel estimation is preferred to pooled OLS, and the Hausman test guides the fixed-versus-random-effects choice. Parametric t-tests and non-parametric Mann-Whitney and Kolmogorov-Smirnov tests are used to compare TE, PTE, and SE distributions across country-income and financial-inclusion-strategy groups.

The panel regressions are also estimated across high-, middle-, and low-income country groups and across different financial-inclusion strategy settings. These subgroup and interaction specifications examine whether the association between individual inclusion indicators and bank efficiency varies with economic development and institutional context. Pearson correlations are used to screen for multicollinearity; because the correlation between lnOUT_DEPO and lnTA exceeds 0.80, lnTA is omitted from models in which outstanding deposits are the principal inclusion variable. These checks strengthen the internal consistency of the reported results, but they do not answer every issue raised by the reviewer. In particular, the original analysis did not include an explicit DEA outlier-deletion sensitivity test, country-specific/metafrontier comparison, clustered country-year standard errors, year fixed effects, fractional-response estimation, or Simar-Wilson bootstrapping. Those items require re-estimation from the underlying dataset and should not be represented as completed in the manuscript until the corresponding results are available.

Table 6: Summary of Robustness Checks

Robustness test	Concern addressed	Interpretation
OLS with White robust standard errors and FEM/REM selection	Heteroskedasticity and unobserved panel heterogeneity	Breusch-Pagan LM and Hausman tests guide the estimator choice.
t-test, Mann-Whitney, and Kolmogorov-Smirnov tests	Differences in TE, PTE, and SE distributions	Efficiency is compared across income and strategy groups.
Income-level and strategy-specific regressions	Heterogeneity across economic and institutional settings	Relationships are allowed to differ across groups and strategies.
Correlation-based multicollinearity screening	Highly correlated regressors	lnTA is omitted from models containing lnOUT_DEPO when correlation exceeds 0.80.

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Note: The table reports only procedures documented in the thesis. Fractional logit, Simar-Wilson bootstrap, winsorisation, lagged-variable models, and dynamic-panel estimators were not reported as completed analyses.

Conclusion

This study examines how separate dimensions of financial inclusion are associated with bank efficiency across 200 commercial banks in six ASEAN economies from 2013 to 2021. The results indicate that access and usage measures do not move in a uniform direction. ATM access per adult, credit-card use, debit-card use, and outstanding loans are positively associated with efficiency in the reported specifications, whereas geographic ATM density, branch density, bank accounts, and outstanding deposits show negative associations. These patterns are economically meaningful because they distinguish the potential cost and revenue implications of different inclusion channels rather than treating financial inclusion as a single composite construct. At the same time, the coefficients should not be read as causal effects, and statistical significance alone is insufficient to establish policy importance given the country-year level of the principal regressors, the common-frontier assumption, and the absence of some robustness procedures requested by the reviewer.

Practical and Country-Sensitive Policy Implications

Policy should be different between access and meaningful use. The number of machines, branches, or accounts should not be the only measure of progress. These indicators are still critical, especially in areas that are not served, but should be supported by evidence of active accounts, affordable payments, productive intermediation of deposits, and customer protections. However, in a country like Singapore where access is already widespread, the focus is more on the efficiency in digital integration, optimizing service delivery, improving cyber security and dealing with the complexities of compliance costs. Banks can go on rationalising their old physical networks in Malaysia and Thailand without compromising the ability of older, rural, and digitally excluded customers to get to a key service.

The average efficiency is lower and the dispersion is greater in the sample for Indonesia and the Philippines. Enabling agent banking, interoperable payment systems, shared infrastructure and strategically deployed service locations can offer scope for wider access at a lower cost than uniform branch expansion. These strategies should be complimented with financial education and consumer protection in order for access to lead to actual consumption rather than dormant accounts. The high pure technical efficiency and low scale efficiency indicate a different priority in Vietnam. Expansion needs to be accompanied by governance, credit-risk management and thoughtful adjustment of operating scale. Deposit-mobilisation programmes in all six countries should be tied to creating productive investment opportunities and credit demand, not simply liquidity. These are suggestions that are derived from the patterns that have been observed and are specific to them. These do not represent country-specific causal estimates as the financial inclusion variables are country-level measures, and the regressions combine banks across economies.

Limitations and Future Research

Several limitations should be acknowledged. First, the sample is confined to commercial banks which may not be representative of development banks, microfinance institutions, cooperative institutions or specialised financial providers. Second, the financial inclusion indicators are

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country-year averages and hence are not designed to reflect the variation in inclusion strategies across individual banks; they are repeated within banks within country-year, and hence do not provide sufficient independent variation for the second stage analysis. Third, DEA scores are dependent on the input-output set and frontier composition chosen. The common frontier allows for a straightforward comparison but does make an assumption of similar banking technologies in the heterogeneous ASEAN systems. Fourth, the country sample is very skewed: Indonesia and Vietnam have far more banks than Singapore, with country averages based on only five banks. Fifth, the original DEA estimates have not been formally tested for sensitivity to influential observations or to the deletion of extreme observations. DEA may be sensitive to extreme observations, but the original estimates were not tested for sensitivity to influential observations or to the deletion of extreme observations.

The study is not able to draw any conclusive causal link between financial inclusion and bank efficiency. Some types of omitted-variable bias can be addressed by bank fixed effects and control variables, but there may be reverse causality, common year shocks, cross-sectional dependence, and time-varying omitted factors. Original second-stage estimates are based on White heteroskedasticity consistent standard errors instead of country-year clustered and multi-way clustered errors, and an unbalanced set of year dummies is not included in the reported fixed-effects models. Future research and ideally the final resubmission, if the data are available, should, therefore, investigate the test of year fixed effects, dependence robust inference, outlier sensitivity of DEA, and alternative frontier structures (country specific or meta frontier). Further inferential checks would be provided by Simar-Wilson bootstrap procedures or other procedures that have been developed for generated DEA scores. Mobile, agent-based, platform, and non-bank indicators should also be included in a potential extension of the indicator beyond 2021, to capture the evolving nature of financial inclusion more fully.

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Appendix

Table A1: Full Regression Results: Control Variables and Diagnostics

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
ln(LLR/TL)	-0.006 (0.006)	-0.006 (0.006)	-0.006 (0.006)	-0.005 (0.006)	-0.005 (0.006)
ln(ROA)	0.025** (0.013)	0.025** (0.013)	0.023* (0.013)	0.021* (0.012)	0.020* (0.012)
ln(NII/TA)	0.055*** (0.015)	0.055*** (0.015)	0.054*** (0.015)	0.048*** (0.014)	0.047*** (0.014)
ln(NIE/TA)	-0.245*** (0.039)	-0.244*** (0.039)	-0.241*** (0.039)	-0.238*** (0.041)	-0.237*** (0.041)
ln(EQASS)	0.064* (0.035)	0.063* (0.035)	0.070** (0.035)	0.059* (0.034)	0.061* (0.034)
ln(TA)	-0.041*** (0.008)	-0.041*** (0.008)	-0.034*** (0.008)	-0.038*** (0.009)	-0.036*** (0.009)
ln(LOANS/TA)	0.052*** (0.012)	0.051*** (0.012)	0.047*** (0.012)	0.044*** (0.012)	0.043*** (0.012)
ln(INF)	-0.022 (0.032)	-0.022 (0.032)	-0.025 (0.032)	-0.019 (0.030)	-0.020 (0.030)
ln(CR3)	1.612*** (0.287)	1.609*** (0.287)	1.647*** (0.288)	1.584*** (0.291)	1.578*** (0.291)
ln(UNEMP)	-0.116*** (0.030)	-0.115*** (0.030)	-0.127*** (0.030)	-0.109*** (0.031)	-0.110*** (0.031)
ln(GDP)	0.133*** (0.024)	0.132*** (0.024)	0.155*** (0.025)	0.128*** (0.025)	0.129*** (0.025)
Constant	-10.570*** (1.157)	-10.531*** (1.158)	-11.408*** (1.197)	-10.214*** (1.183)	-10.178*** (1.179)
R^2	0.343	0.341	0.329	0.352	0.349
Wald χ^2	176.65***	174.22***	182.47***	189.34***	187.91***
BPLM χ^2	766.03***	761.48***	790.69***	–	–
Hausman	–	–	–	38.47***	37.21***

Note: The dependent variable is ln(TE). Heteroskedasticity-robust standard errors are in parentheses. Models 1-3 are pooled OLS; Models 4-5 are fixed effects. ***, **, and * denote significance at the 1%, 5%, and 10% levels.