Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 2329-2351



ADVANCED INTERNATIONAL JOURNAL OF BUSINESS, ENTREPRENEURSHIP AND SMES (AIJBES)
www.gaexcellence.com/aijbes

FINANCIAL INCLUSION AND BANK EFFICIENCY IN THAILAND: EVIDENCE FROM A TWO-STAGE DEA APPROACH

Nabilah Abdul Shukur[1*], Salwani Affandi[2], Fadzlan Sufian[3]

[1]Faculty of Business and Management, Universiti Teknologi MARA Cawangan Negeri Sembilan
nabilah@uitm.edu.my https://orcid.org/0000-0002-3533-6888
[2]Faculty of Business and Management, Universiti Teknologi MARA Cawangan Terengganu
salwaniaffandi@uitm.edu.my https://orcid.org/0009-0001-7270-5259
[3]Faculty of Business and Management, Universiti Teknologi MARA Cawangan Melaka
fadzlansufian@uitm.edu.my https://orcid.org/0000-0001-7092-2324
[*]Corresponding Author

Article Info:

Article history:
Received date: 30.07.2026
Revised date: 20.08.2026
Accepted date: 27.09.2026
Published date: 30.09.2026

To cite this document:

Shukur, N. A., Affandi, S., & Sufian, F. (2026). Financial Inclusion and Bank Efficiency in Thailand: Evidence from A Two-Stage Dea Approach. *Advanced International Journal of Business Entrepreneurship and SMEs, 8*(29), 2329-2351.

Abstract:

This study examines the relationship between financial inclusion and bank efficiency in Thailand during 2013-2021, a period marked by high levels of formal financial access and rapid growth in digital financial services. Bank efficiency is estimated using an input-oriented Data Envelopment Analysis (DEA), with technical efficiency (TE) decomposed into pure technical efficiency (PTE) and scale efficiency (SE). The Thai sample consists of 211 bank-year observations from 26 commercial banks and foreign-bank branches. A broader ASEAN-6 panel of 1,500 bank-year observations is used to construct the efficiency frontier and support the second-stage estimation of Thailand-specific associations. The average annual efficiency scores are 0.599 for TE, 0.682 for PTE and 0.867 for SE, suggesting that inefficiency is more closely related to managerial and operational factors than to scale. The second-stage results show that the relationship between financial inclusion and efficiency varies across indicators. ATM density is statistically insignificant, while branch density per 1,000 km² is positively associated with efficiency. In contrast, deposit accounts, credit cards and outstanding deposits are negatively associated with efficiency. These findings suggest that, in a relatively mature financial system, expanding access alone may not necessarily generate additional efficiency gains. Greater attention may instead be needed on active financial-service usage, efficient delivery channels and the productive deployment of bank funding.

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 2329-2351
DOI: 10.35631/AIJBES.829134 **Keyword:**

Bank Efficiency; Data Envelopment Analysis; Digital Payments; Financial Inclusion; Thailand; Two-Stage DEA

© The authors (2026). This is an Open Access article distributed under the terms of the Creative Commons Attribution (CC BY NC) (http://creativecommons.org/licenses/by-nc/4.0/), which permits non-commercial re-use, distribution, and reproduction in any medium, provided the original work is properly cited. For commercial re-use, please contact aijbes@gaexcllence.com.

Introduction

Financial inclusion is often measured by whether people can reach or own a formal financial product. For banks, an account that is rarely used or an additional card, ATM or branch that generates little business, may add cost without adding much output. For this reason, the analysis distinguishes access from effective use rather than treating account ownership as a complete measure of inclusion (Beck et al., 2007; Allen et al., 2016; Demirgüç-Kunt et al., 2022). The expected link with bank efficiency is not one-sided. Reaching more customers can strengthen deposits, widen fee and interest income, and allow technology or compliance costs to be spread over a larger volume of business. These channels are consistent with the intermediation role of banks and with earlier evidence on deposit stability and bank performance (Sealey and Lindley, 1977; Diamond, 1984; Ahamed et al., 2021). The same expansion also has a cost side. Banks spend on onboarding, physical outlets, ATMs, digital systems, cybersecurity, financial literacy and borrower monitoring. When customers use those services only occasionally, the cost may arise before the additional business does (Le et al., 2019; Yadav et al., 2022; Banna et al., 2023). The direction of the relationship therefore has to be established empirically for each inclusion channel.

Thailand offers a useful setting because financial access was already broad when digital payments began to expand rapidly. Between 2013 and 2021, the banking system was therefore dealing with two developments at once: wider digital use and a changing role for physical delivery channels. Financial Sector Master Plan Phase III, the National e-Payment programme and the payment-system roadmaps connected digitalisation with access, efficiency, consumer protection and financial stability (Bank of Thailand, 2016a, 2016b, 2017, 2019). The Fourth Payment Systems Roadmap for 2019-2021 placed particular emphasis on interoperability, innovation, information, inclusion and resilience (Bank of Thailand, 2017, 2019, 2021a). This makes Thailand suitable for examining not only whether inclusion expanded, but also whether its different forms were associated with bank efficiency.

Most of the existing studies of Thai banks shows about their efficiency but much less about how inclusion enters that picture. Earlier DEA work documents clear differences in efficiency across banks and links those differences to technical change, management and operating capability (Bunpong and Chancharat, 2012; Suebpongsakorn et al., 2016). Buakes (2023) likewise shows the relevance of the intermediation approach for specialised financial institutions. What remains less developed is the connection between bank-level efficiency and

separate measures of branches, ATMs, accounts, cards, deposits and loans during Thailand's digital transition. This gap matters because formal access was already high by the end of the sample. At that stage of market development, one more account or access point need not produce the same gain as it would in a less financially developed setting.

Four points remain unresolved in the literature. Composite inclusion indices are useful for comparing overall financial access, but they do not reveal whether an estimated relationship is being driven by branches, ATMs, accounts, cards, deposits or credit (Sarma, 2008; Amidzic et al., 2014; Park and Mercado, 2018). Thai DEA studies have also not brought these separate channels together in one bank-efficiency framework. A further problem is statistical: national inclusion indicators are repeated across banks within the same year. Thailand has nine annual observations for each national series, even though the matched bank panel contains 211 bank-year observations. Treating those repeated values as independent bank-level information can make the estimates look more precise than they really are. Finally, a total efficiency score alone does not show whether the main gap comes from management and operations or from bank scale.

The empirical design is intended to deal with those issues directly. First, an input-oriented DEA model is used to estimate TE, PTE and SE. The Thai sample contains 211 bank-year observations from 26 commercial banks and foreign-bank branches. The wider ASEAN-6 sample - Indonesia, Malaysia, the Philippines, Singapore, Thailand and Vietnam - is retained because it improves discrimination of the DEA frontier and provides the country-year variation needed for the second-stage interaction terms. The discussion of results, however, remains focused on Thailand. In the second stage, bank and year fixed effects are combined with Thailand-specific interactions, and the standard errors are clustered at the country-year level to match the level at which the inclusion variables actually vary.

The paper therefore makes its contribution in both measurement and interpretation. It does not reduce financial inclusion to one composite index; physical access, accounts, payment instruments, deposits and loans are examined separately. It also reports the TE decomposition so that operating inefficiency can be distinguished from scale inefficiency. The second-stage specification is designed around the country-year nature of the inclusion data rather than treating those indicators as if they varied across individual banks. Substantively, the study asks what financial inclusion means for efficiency once access is already widespread. In that setting, additional products are more likely to matter when they are actively used, generate income or provide funding that banks can deploy productively. This interpretation has direct relevance for customer activation, branch-network design, digital delivery and intermediation quality.

Three questions guide the analysis. First, how did Thai bank efficiency move over 2013-2021? Second, was the remaining inefficiency mainly operational or scale-related? Third, how were the separate dimensions of financial inclusion associated with bank efficiency? The following section describes the Thai banking and payment environment before the paper turns to theory, data and methods, empirical results, discussion and policy implications.

Thailand's Banking and Financial Inclusion Environment

Commercial banks are central to Thailand’s financial system through their roles in deposit mobilisation, credit allocation and payments. The sector contains large domestic banking groups, smaller domestic institutions and foreign-bank branches, and that mix has implications

for efficiency. Larger banks may be able to spread technology, compliance and risk-management costs across a wider customer base. Smaller institutions, in contrast, may rely more on specialised products, geographic niches or corporate relationships. Scale advantages are therefore possible, although a more concentrated market can also reduce competitive pressure (Berger and Mester, 1997; Casu and Molyneux, 2003; Nguyen et al., 2023).

Thailand's reform programme did not take the form of a single financial-inclusion policy. It evolved through a series of financial-sector initiatives. Financial Sector Master Plan Phase II stressed lower operating costs, competition, access and financial infrastructure. Phase III, covering 2016-2020, moved toward a system described as competitive, inclusive, connected and sustainable. Digitalisation, efficiency, access, professional development, financial literacy, consumer protection and risk management were treated as parts of the same policy framework (Bank of Thailand, 2016a). This is relevant here because the Thai policy setting did not treat access as an objective separate from efficiency.

Retail payments were one of the clearest areas of change. The 2016 Payment Systems Annual Report documents the introduction of PromptPay and the expansion of electronic data-capture terminals under the National e-Payment Master Plan (Bank of Thailand, 2016b). PromptPay made retail transfers easier by allowing customers to use a mobile-phone or national identification number as the payment identifier. Subsequent reforms strengthened the infrastructure around electronic payments. By 2019-2021, the Fourth Payment Systems Roadmap was organised around interoperability, innovation, information, inclusion and resilience (Bank of Thailand, 2017, 2019, 2021a).

The data indicate that access increased not evenly across all avenues. ATMs per 100,000 adults increased from about 111.3 in 2013 to 132.4 in 2018 before falling back to 123.9 in 2021. Branches moved in the opposite direction, from 12.09 to 9.65 per 100,000 adults between 2013 and 2021. During the same time period, deposit accounts grew from about 1150 to 1386 per 1000 adults, credit cards jumped from 334 to 429, and debit cards grew from 782 to 1108 per 1000 adults. These are supply-side counts and may be higher than population ownership as one person may own more than one product. Global Findex provides a helpful indicator of ownership: In 2021, 96 percent of Thai adults reported ownership of an account (Demirgüç-Kunt et al., 2022).

Those movements collectively seem more related to shifting delivery methods than to the withdrawal of financial services. The number of accounts, cards and digital payments increased, while the number of branches decreased. Mobile banking, digital payments, assisted channels can ensure access without the same distribution points. They have different cost bases, too. The cost of a digital transaction (after the platform is built) can be low, whereas the cost of a branch or ATM is higher and involves premises, staff, cash handling, security and maintenance.

The costs of a digital transaction, once the platform is developed, are comparatively low while the costs associated with a branch or ATM are significantly higher, including the costs of premises, staff, cash handling, security and maintenance. Despite that, online banking isn't free. Banks are still investing in software, Cyber Security, fraud prevention, authentication and compliance. So, the efficiency gain would depend on how much use is made of that service and whether the cost of the service is offset by such use.

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 2329-2351

The Bank of Thailand's household access surveys bear this out with regard to availability versus use. The surveys do not only inquire on access to services, but also on the use of the services and the satisfaction with the products (Bank of Thailand, 2020). The owner of an account can use cash for most purchases and transactions, or the customer may have multiple cards and use one frequently. Those differences impact both the revenue and servicing cost. In this study, Thailand's involvement in the Alliance for Financial Inclusion Maya Declaration is considered as an institutional environment, and not as a policy treatment. It cannot determine a within-country policy coefficient because their status is not changed in 2013-2021.

The pandemic provides a helpful stress event to the sample. In 2020, the growth of banking-system loans was higher than its growth in 2019, rising by 5.1 percent in 2020 compared to 2.0 percent in 2019, due to large firms' temporary reorientation of funding to the banking system, while consumer lending slowed (Bank of Thailand, 2021b). Thai banks were in a strong position when the period started. The capital adequacy ratio at the end of 2020 was 20.1 percent, coverage of NPLs was 149.2 percent and the liquidity coverage ratio was 179.6 percent. Even profitability took a hit due to provisions, as the ROA fell to 0.65 percent and the net interest margin to 2.51 percent. Capital and provisioning were kept high in 2021, and borrower-support measures helped to prevent a worsening of the asset quality in the short term (Bank of Thailand, 2021b, 2022).

TE declined from 0.666 in 2019 to 0.629 in 2020 and was 0.625 in 2021. The pandemic period is mentioned here only as a context to this movement. Provisioning, the reallocation of resources and extra risk-management activity all rose at the same time, but the DEA scores were not able to distinguish the impact of each of these. Overall, Thailand has high formal access, a strong digital payment system, and good prudential buffers. It's helpful in assessing if subsequent growth in accounts, cards or access points can continue to drive efficiency gains in the same manner as previous growth.

Table 1: Financial Inclusion Indicators for Thailand, 2013-2021

Indicator	2013	2016	2019	2021
Banks in matched second-stage sample	19	24	25	24
ATMs per 100,000 adults	111.28	130.78	130.46	123.93
Commercial-bank branches per 100,000 adults	12.09	12.35	11.24	9.65
Deposit accounts per 1,000 adults	1,149.95	1,211.91	1,327.43	1,385.64
Credit cards per 1,000 adults	333.95	356.16	414.40	429.49
Debit cards per 1,000 adults	781.65	957.72	1,118.47	1,107.58

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 2329-2351

Indicator	2013	2016	2019	2021
Outstanding commercial-bank loans (% of GDP)	72.36	72.37	70.75	80.98

Source: IMF Financial Access Survey and author's calculations.
Notes: Financial-inclusion indicators are supply-side measures from the IMF Financial Access Survey as transformed in the analytical workbook. Account and card counts can exceed population ownership rates because individuals may hold multiple products.

Theoretical Framework and Literature Review

The interpretation rests on three related ideas. The first is financial intermediation. Banks create value by mobilising deposits, screening and monitoring borrowers, and transforming maturities and risks (Sealey and Lindley, 1977; Diamond, 1984). Financial inclusion can support that process when new customers bring stable deposits, regular payment activity or information that improves credit assessment. The gain, however, depends on what follows access. An account or payment relationship has to generate transactions, funding that can be used, or credit that is priced appropriately. Cross-country evidence likewise shows that the institutional and regulatory environment affects whether inclusion is translated into better bank performance (Ahamed et al., 2021).

A second issue is scale. Banking requires large, fixed investments in technology, cybersecurity, risk management, branch networks and regulatory reporting. More customers and transactions can spread those costs, but the benefit does not continue indefinitely. Legacy systems, organisational complexity, additional management layers and excess capacity may eventually offset the scale advantage (Berger and Humphrey, 1997; Berger and Mester, 1997). DEA is useful in this context because TE can be separated into PTE and SE. PTE reflects managerial and operating performance under VRS, while SE indicates how close a bank is to the most productive operating scale (Charnes et al., 1978; Banker et al., 1984).

The third idea is institutional. The same financial product can have different efficiency implications depending on regulation, payment infrastructure, consumer protection, financial literacy, contract enforcement and technological readiness (North, 1990; Suddaby, 2010; Scott, 2014). A Thai branch that continues to handle advisory work, complex transactions or customer assistance may justify its cost even when routine payments move online. Another branch may not. Accounts are similar: some generate active balances and payment flows, while others remain largely dormant. The institutional and organisational setting therefore affects how financial access is converted into productive use.

The empirical literature is consistent with that ambiguity. Financial inclusion has long been treated as multidimensional, and several composite measures were developed to summarise access and use (Beck et al., 2007; Sarma, 2008; Arora, 2010; Amidzic et al., 2014; Park and Mercado, 2018). Such indices are useful for cross-country comparison, but they make it difficult to identify the specific component associated with bank efficiency. Le et al. (2019), using Asian data, report wider inclusion together with lower financial efficiency but stronger sustainability. Ahamed et al. (2021), in contrast, find stronger bank performance where inclusion supports stable funding within a favourable regulatory setting. The difference

between these findings may reflect different channels or different stages of financial development rather than a simple contradiction.

Studies closer to the present question also report mixed results. Yadav et al. (2022) show that technology-based delivery can reduce the resources required for financial inclusion in Indian private banks. Banna et al. (2023), using a Simar-Wilson approach, find efficiency gains from fintech-based inclusion, although the relationship differs across banking systems and business models. Work on microfinance also shows that outreach and efficiency can coexist when operating design and financial sustainability are managed carefully (Haq et al., 2010). In Thailand, Bunpong and Chancharat (2012) and Suebpongsakorn et al. (2016) document variation in commercial-bank efficiency and productivity, while Buakes (2023) applies the intermediation approach to specialised financial institutions. What these studies do not examine is the relationship between disaggregated national inclusion indicators and Thai bank efficiency while accounting for the limited annual variation in those indicators.

The second stage presents a separate econometric issue because DEA scores are estimated and bounded rather than directly observed. Simar and Wilson (2007) recommend bootstrap procedures for conventional two-stage DEA models. McDonald (2009), however, shows that least-squares methods can still be informative under suitable specifications and cautions against treating Tobit as the automatic choice. Fractional-response models provide another option for variables bounded between zero and one (Papke and Wooldridge, 1996). In this paper, log TE is used in the main fixed-effects models and TE in levels is used as a robustness check. Since the inclusion variables vary at country-year level, the standard errors are clustered at the same level.

Physical access is an example of why there cannot be a single sign in advance. Branches and ATMs save on travel expenses and can help customers get acquired, offer advice and relationship services that can't be replicated online. Both are also fixed-cost channels and, at the same time, can become underutilized with the move of routine transactions to digital platforms (Bernini and Brighi, 2018). The network could be more selective than in the early part of the sample, due to the declining branch ratio and increasing digital usage in Thailand. Likewise, with accounts and with cards. They can also create revenue, fees and customer data, but dormant or under-balanced products still need to be compliant, technologically driven, monitored for fraud and supported by customers. The issue of efficiency is less important in this case because the usage of the product by the customers is more important than the issuance (Allen et al., 2016; World Bank, 2022).

Deposits and loans are more closely related to the basic intermediation function, but the relationships to be expected with efficiency are not automatic. Deposits can be a source of stable and relatively cheap funding. When demand for credit is low, appetites for risk are conservative, or when liquidity and capital requirements are limiting the deployment, however, extra deposits may not result in proportionate earning assets. Loans, on the other hand, provide interest income, and must be screened, monitored and capitalized and provisioned. Their contribution, therefore, relies on the credit quality and risk pricing (Ahamed et al., 2021; Bank of Thailand, 2021b, 2022). The other cost trade-off of digital finance is that offline routine transactions could become less expensive, but the banks have to invest in cybersecurity, cloud systems, fraud analysis, applications and skills of their personnel during the transition (DeYoung et al., 2007; Ozili, 2018).

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 2329-2351

Risk is also a consideration in the interpretation. A more diversified deposit base can help stabilise funding, a more diverse loan portfolio can help diversify loan risk, but when information systems are weak, extending credit to new borrowers or thin-file borrowers can increase adverse-selection, monitoring and loss costs. Efficiency, therefore should be viewed along with prudential strength. Thai banks were well capitalised and provisioned at the onset of the pandemic, meaning they had the capacity to absorb risk, but this does not imply that all new accounts, cards, deposits and loans necessarily resulted in improved efficiency at the time. The extent of the inclusion is estimated separately for each indicator, rather than requiring a common positive relationship.

The theory suggests there is a channel-specific relationship, not a single financial-inclusion coefficient. Further access can facilitate the efficiency when it activates customers, spreads fixed costs or helps the generation of asset values (earning assets). A similar expansion may have limited value if products are duplicative, are only used lightly, or are expensive to service, or if there is no productive way to raise extra funds. These mechanisms can be helpful in interpreting the estimates but the data available do not capture activity at the customer level or cost-to-serve. These should not be interpreted in terms of fixed causal channels, however.

Data and Methodology

The empirical analysis is carried out in two stages. Bank balance-sheet variables are taken from Fitch Connect database, financial-inclusion indicators from the IMF Financial Access Survey and macroeconomic controls from the World Development Indicators. The regional panel contains 1,500 bank-year observations from Indonesia, Malaysia, the Philippines, Singapore, Thailand and Vietnam over 2013-2021. Thailand contributes 211 observations from 26 commercial banks and foreign-bank branches. The regional sample is used to construct the DEA frontier and to provide enough country-year variation for the Thailand interaction terms. All substantive interpretation in the paper remains Thailand-specific, and no country ranking is reported.

The DEA stage follows the intermediation approach of Sealey and Lindley (1977). Deposits, personnel expenses and the book value of fixed assets are treated as inputs. Loans, investments and securities, and net interest income are treated as outputs. Monetary variables are taken from the common-currency values in the source database. An input orientation is used because bank management has more direct influence over resource use and operating cost than over market demand for loans and investment opportunities.

Overall, TE is estimated using the Charnes-Cooper-Rhodes (CCR) model under constant returns to scale (CRS). A score of one place the bank-year observation on the estimated frontier; a lower score shows the proportional reduction in inputs needed to reach that frontier while holding outputs constant (Charnes et al., 1978). PTE is estimated using the Banker-Charnes-Cooper model under variable returns to scale (BCC/VRS), with the usual convexity restriction (Banker et al., 1984). Scale efficiency is calculated as SE = TE/PTE. A non-increasing-returns-to-scale extension is then used to classify each observation as CRS, IRS or DRS (Coelli et al., 2005). This makes it possible to separate managerial or operating inefficiency from inefficiency associated with scale.

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 2329-2351

The second-stage dependent variable is ln (TE). Each inclusion indicator is logged and entered in a separate regression because the access and usage measures are closely related. The model includes bank fixed effects, year fixed effects, bank controls and macroeconomic controls. A Thailand interaction is added for each inclusion variable, and the Thailand-specific association is obtained from the sum of the common coefficient and the interaction term. The inclusion variables change only at country-year level, so standard errors are clustered at that level. With six countries over nine years, the panel provides 54 country-year clusters.

Table 2: Variable Definitions and Expected Economic Channels

Variable	Measurement	Source	Economic channel
TE	Input-oriented CRS DEA score	Fitch Connect and DEAP	Dependent variable
PTE	Input-oriented VRS DEA score	Fitch Connect and DEAP	Managerial/operating efficiency
SE	TE divided by PTE	Fitch Connect and DEAP	Scale efficiency
ATMs/100,000 adults	Logged demographic ATM density	IMF FAS	Physical access and possible diminishing returns
Branches/100,000 adults	Logged demographic branch density	IMF FAS	Access and relationship services versus fixed costs
ATMs/1,000 km²	Logged geographic ATM density	IMF FAS	Spatial access
Branches/1,000 km²	Logged geographic branch density	IMF FAS	Spatial network and fixed cost
Deposit accounts/1,000 adults	Logged deposit-account density	IMF FAS	Customer base, dormancy and saturation
Credit cards/1,000 adults	Logged issued credit-card density	IMF FAS	Fee/credit income versus servicing and risk
Debit cards/1,000 adults	Logged issued debit-card density	IMF FAS	Electronic usage and payment-channel substitution
Outstanding deposits	Logged commercial-bank deposits	IMF FAS	Stable funding versus excess liquidity
Outstanding loans/GDP	Logged lending depth	IMF FAS	Intermediation output versus monitoring/provisioning

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 2329-2351

Variable	Measurement	Source	Economic channel
Bank controls	Risk, profitability, diversification, cost, capital, size and lending intensity	Fitch Connect	Institution-specific determinants
Macro controls	Inflation, CR3, unemployment and GDP	World Development Indicators	Country-year environment

Source: Author's compilation based on Fitch Connect, IMF Financial Access Survey and World Development Indicators.

Empirical Results

Efficiency Levels and Decomposition

The efficiency series does not show a smooth trend. TE was 0.517 in 2013 and slipped to 0.486 in 2014. It then improved through 2015 and 2016, reached 0.674 in 2017 and peaked at 0.688 in 2018. The score eased to 0.666 in 2019, 0.629 in 2020 and 0.625 in 2021. Averaging the nine annual means gives 0.599. Because the panel is unbalanced, an observation-weighted mean was also calculated across all 211 Thai bank-years; this is about 0.607. Reporting both figures avoids giving the same weight to years with different numbers of banks.

The decomposition gives a clearer view of where the efficiency gap lies. Mean PTE is 0.682, compared with 0.867 for SE. Put differently, the average distance from the frontier is 31.8 percent for PTE and 13.3 percent for scale efficiency. The larger PTE gap indicates more room for improvement in management, operating processes and resource use than in scale adjustment alone. Scale still matters, but it is not the larger average source of inefficiency in the Thai sample.

Returns-to-scale classifications reinforce that point but also show considerable variation across banks. Of the 211 bank-year observations, 45 are classified as CRS, 138 as DRS and 28 as IRS, corresponding to 21.3, 65.4 and 13.3 percent of the sample. DRS is therefore the dominant category, suggesting that many observations lie above the most productive scale. The IRS cases show that some smaller institutions still had scope to expand. The Thai sector is thus not characterised by one scale problem; management and scale differ across institutions and over time.

The timing of the changes is informative, although it cannot be treated as evidence of a policy effect. TE and PTE improved between 2015 and 2018, which overlaps with Financial Sector Master Plan Phase III, PromptPay and wider e-payment infrastructure (Bank of Thailand, 2016a, 2016b, 2017). Efficiency moderated afterwards, while technology migration continued and the pandemic followed. During such transitions, banks may have to run old and new systems together, retrain staff and spend more on cybersecurity (DeYoung et al., 2007; Ozili, 2018). These developments provide context for the DEA pattern, but the DEA design does not identify their causal contribution.

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 2329-2351

The 2020 decline can also be viewed alongside system-wide banking data. Credit continued to expand, yet provisioning costs increased and profitability weakened as banks prepared for possible deterioration in asset quality (Bank of Thailand, 2021b). Those activities use resources without necessarily raising the DEA outputs in the same period. SE then increased from 0.837 in 2020 to 0.899 in 2021, suggesting some recovery in operating scale, although PTE remained below its 2018 peak.

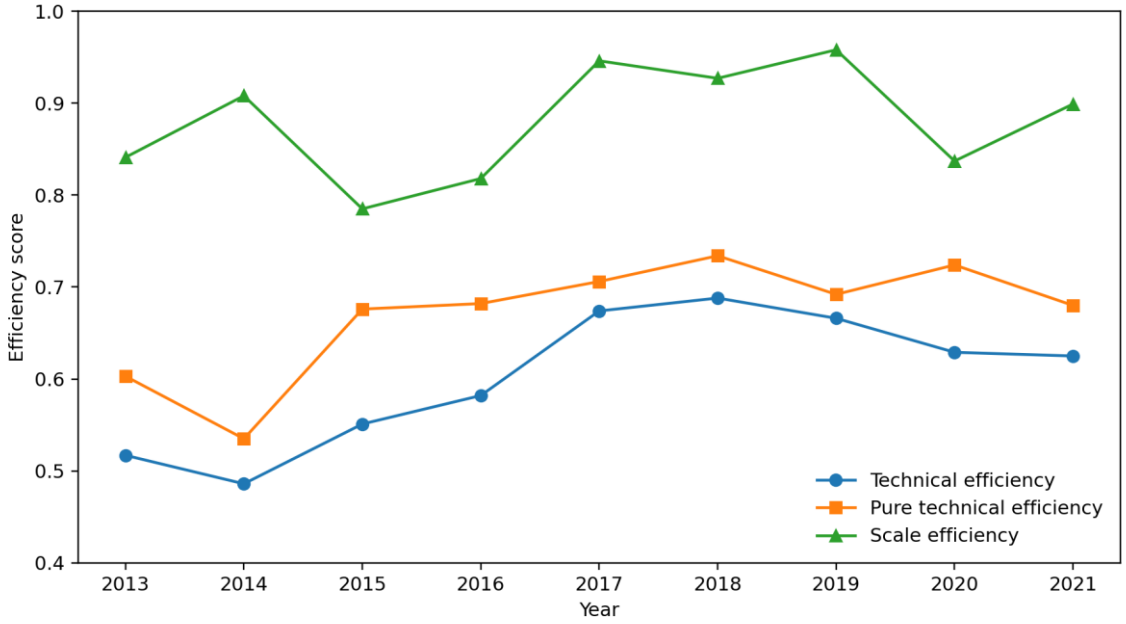


Figure 1: Annual TE, PTE and SE of Thai Banks, 2013-2021

Source: Author's computation from the verified DEAP output.

Table 3: Annual DEA Efficiency and Returns-to-Scale Classifications

Year	N	TE	PTE	SE	CRS	DRS	IRS
2013	19	0.517	0.603	0.841	1	14	4
2014	21	0.486	0.535	0.908	1	17	3
2015	24	0.551	0.676	0.785	5	18	1
2016	24	0.582	0.682	0.818	6	16	2
2017	25	0.674	0.706	0.946	5	16	4
2018	25	0.688	0.734	0.927	8	16	1
2019	25	0.666	0.692	0.958	6	11	8
2020	24	0.629	0.724	0.837	6	16	2
2021	24	0.625	0.680	0.899	7	14	3
Mean / total	211	0.599	0.682	0.867	45	138	28

Source: Author's computation from the verified DEAP output.

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 2329-2351

Table 4: Summary of Thai Bank Efficiency, 2013-2021

Dimension	Mean score	Inefficiency	Interpretation	Bank-years	Share
Technical efficiency (TE)	0.599	40.1%	Overall input-use efficiency	211	100.0%
Pure technical efficiency (PTE)	0.682	31.8%	Managerial and operating efficiency	211	100.0%
Scale efficiency (SE)	0.867	13.3%	Efficiency of operating scale	211	100.0%
Constant returns to scale (CRS)	-	-	Operating at the most productive scale	45	21.3%
Decreasing returns to scale (DRS)	-	-	Operating above the most productive scale	138	65.4%
Increasing returns to scale (IRS)	-	-	Operating below the most productive scale	28	13.3%

Source: Author's computation from the verified DEAP output.

Descriptive Statistics

The descriptive statistics also explain why the second-stage design needs care. Logged ATM density per 100,000 adults has a standard deviation of only 0.048, and logged branch density has a standard deviation of 0.083. More importantly, each Thai inclusion series contains only nine different annual values even though the matched panel contains 211 bank-year observations. Repeating the same national value across banks does not create new independent information. The interaction model and country-year clustering are used to reflect that feature of the data.

Table 5: Descriptive Statistics for the Thai Second-Stage Sample (N = 211)

Variable	Mean	Std. dev.	Minimum	Maximum
ln(TE)	-0.608	0.457	-1.772	0.000
ln(LLR/TL)	-4.923	1.408	-11.326	-2.306
ln(ROA)	-4.798	0.896	-10.836	-2.347

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 2329-2351

Variable	Mean	Std. dev.	Minimum	Maximum
ln(NII/TA)	-4.754	0.928	-10.326	-2.303
ln(NIE/TA)	-4.199	0.579	-5.595	-2.941
ln(EQASS)	-1.816	0.566	-2.861	-0.014
ln(TA)	12.719	1.426	9.773	15.282
ln(Loans/TA)	-0.748	0.798	-4.565	-0.101
ln(Inflation)	-0.590	1.055	-2.307	0.782
ln(CR3)	3.944	0.034	3.863	3.980
ln(Unemployment)	-0.339	0.405	-1.386	0.191
ln(GDP)	26.773	0.059	26.677	26.855
ln(ATMs per 100,000 adults)	4.847	0.048	4.712	4.886
ln(Branches per 100,000 adults)	2.447	0.083	2.267	2.528
ln(ATMs per 1,000 km²)	4.734	0.043	4.628	4.769
ln(Branches per 1,000 km²)	2.559	0.069	2.403	2.626
ln(Deposit accounts per 1,000 adults)	7.142	0.064	7.047	7.234
ln(Credit cards per 1,000 adults)	5.935	0.090	5.811	6.063
ln(Debit cards per 1,000 adults)	6.898	0.124	6.661	7.020
ln(Outstanding deposits)	16.266	0.126	16.074	16.472
ln(Outstanding loans/GDP)	4.304	0.047	4.259	4.394

Source: Author's computation.

Financial Inclusion and Bank Efficiency

The estimates in Table 6 vary noticeably across inclusion channels. The two ATM measures are not statistically significant. Branches per 100,000 adults are positive but insignificant, whereas branches per 1,000 km^2 have a Thailand-specific coefficient of 0.508 with $p = 0.090$. This is weak evidence rather than a strong result. One possible reading is that, after several years of network rationalisation, the remaining branches are concentrated in locations where relationship banking and assisted services still justify their cost. The ATM results tell a different

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 2329-2351

story: when ATM density is already high and digital alternatives are expanding, another machine may contribute little to measured productivity. Because channel-level transaction volumes are not observed, both interpretations remain tentative.

Deposit accounts show a stronger statistical relationship. A 1 percent increase in deposit accounts per 1,000 adults is associated with an estimated 1.032 percent reduction in efficiency, with $p = 0.045$. Thailand already had more than one deposit account per adult in the supply-side data throughout the sample. Additional accounts may therefore include secondary or lightly used relationships rather than newly banked customers. Banks still incur onboarding, KYC, data-storage, fraud-monitoring and service costs for those accounts. The dataset does not contain customer-level activity or balance information, so account dormancy cannot be tested directly. The coefficient is therefore consistent with a saturation or low-use interpretation, but it does not prove that mechanism (Allen et al., 2016; World Bank, 2022).

Credit cards produce a similar pattern. The Thailand-specific coefficient is -0.745 and is significant at the 5 percent level ($p = 0.027$). The variable measures cards issued, not transaction frequency, revolving balances, risk-adjusted income or servicing cost. In a mature market, additional issuance can therefore increase marketing, rewards, fraud-management or support costs without a proportionate rise in output. The data do not allow those channels to be separated. Debit cards are also negative (-0.419), but the estimate is not statistically significant ($p = 0.125$). The rapid spread of PromptPay and QR-based transfers also means that card counts alone are an increasingly incomplete measure of digital-payment activity.

Outstanding deposits have the largest statistically significant negative coefficient in Table 6 (-0.956, $p = 0.004$). Deposits are valuable as a source of stable funding, but their contribution to measured production efficiency depends on whether the additional funds are translated into loans, investments or income (Ahamed et al., 2021). A negative coefficient is therefore compatible with periods in which credit demand is weak, risk appetite is conservative or banks deliberately hold larger liquidity buffers. The regression does not observe those mechanisms directly. The pandemic context makes this interpretation plausible because Thai banks maintained high liquidity and provisioning (Bank of Thailand, 2021b, 2022). It should not, however, be taken to mean that deposit mobilisation itself is undesirable.

The loan result is less conclusive. Outstanding loans relative to GDP have a coefficient of -0.398 in the log-efficiency model, but the estimate is not statistically significant ($p = 0.320$). Aggregate lending depth does not distinguish between well-priced credit and lending that carries high screening, monitoring, capital or provisioning costs. In 2020, lending grew while ROA and the net interest margin declined as provisions increased (Bank of Thailand, 2021b). That episode shows why the expected sign is not obvious, but it does not establish that lending caused lower efficiency.

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 2329-2351

Table 6: Thailand-Specific Marginal Associations with Bank Efficiency

Indicator	Thailand-specific marginal association	Clustered SE	p-value	Interpretation
ATMs/100,000 adults	0.027	0.517	0.958	Statistically insignificant
Branches/100,000 adults	0.237	0.274	0.390	Positive, but insignificant
ATMs/1,000 km²	0.304	0.512	0.555	Statistically insignificant
Branches/1,000 km²	0.508	0.295	0.090	Positive; weak evidence at 10%
Deposit accounts/1,000 adults	-1.032	0.502	0.045	Negative; significant at 5%
Credit cards/1,000 adults	-0.745	0.326	0.027	Negative; significant at 5%
Debit cards/1,000 adults	-0.419	0.269	0.125	Negative, but insignificant
Outstanding deposits	-0.956	0.317	0.004	Negative; significant at 1%
Outstanding loans/GDP	-0.398	0.397	0.320	Negative, but insignificant

Source: Author's fixed-effects regression estimates.

Notes: The dependent variable is ln (TE). Each row reports the combined Thailand-specific marginal association from a separate bank- and year-fixed-effects regression with bank-level and macroeconomic controls. Standard errors are clustered at the country-year level. N = 1,500 bank-year observations; clusters = 54. The wider panel covers Indonesia, Malaysia, the Philippines, Singapore, Thailand and Vietnam. Coefficients for other countries are not reported because the substantive analysis focuses on Thailand.

The control variables in the representative deposit model have economically familiar signs. ROA is positively associated with efficiency, non-interest expenses are negative, and capitalisation is positive. These patterns are consistent with the wider efficiency literature. More profitable banks may have greater capacity to invest in technology and risk management; high operating expenses absorb resources; and stronger capital can reduce distress-related costs (Berger and Mester, 1997; Casu and Molyneux, 2003). Bank size is not significant after fixed effects, which means that within-bank asset growth is not systematically related to higher efficiency in this specification.

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 2329-2351

Robustness Analysis

Using TE in levels leads to much the same overall pattern. Geographic branch density remains positive and becomes statistically significant (β = 0.354, p = 0.017). Deposit accounts (β = -0.563, p = 0.044), credit cards (β = -0.382, p = 0.022) and outstanding deposits (β = -0.556, p = 0.003) remain negative and significant. Outstanding loans also becomes negative and significant in this specification (β = -0.440, p = 0.029). The ATM and debit-card estimate remain insignificant. The robustness exercise therefore changes some significance levels, but it does not alter the broad contrast between the branch result and several stock measures of accounts, cards and deposits.

Table 7: Robustness Test – Thailand Marginal Associations Using TE in Levels

Indicator	Thailand-specific marginal association	Clustered SE	p-value
ATMs/100,000 adults	-0.024	0.318	0.941
Branches/100,000 adults	0.218	0.133	0.107
ATMs/1,000 km²	0.153	0.321	0.635
Branches/1,000 km²	0.354	0.143	0.017
Deposit accounts/1,000 adults	-0.563	0.272	0.044
Credit cards/1,000 adults	-0.382	0.162	0.022
Debit cards/1,000 adults	-0.211	0.141	0.140
Outstanding deposits	-0.556	0.178	0.003
Outstanding loans/GDP	-0.440	0.196	0.029

Source: Author's robustness regression estimates.

The robustness results mainly strengthen confidence in the direction of the estimates. They do not turn the relationships into causal effects. Geographic branch density remains positive, the ATM evidence remains weak, and several account, card and balance-sheet stock measures remain negative. For a mature financial system, this pattern is consistent with diminishing returns to numerical expansion. The data still cannot identify whether saturation, low use, servicing cost or limited liquidity deployment is the channel behind those coefficients.

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 2329-2351

Discussion

A useful way to read the findings is to consider where Thailand was in the financial-inclusion process during the sample. Informal access was already prevalent. Another account, card or access point was therefore not necessarily bringing an excluded customer into formal finance for the first time. It is the outcome of the product's existence that is important for efficiency - the number of transactions made by the customers, the number of balances kept, the number of borrowings, or the number of times they earn enough income to make up for the cost of the relationship. This accounts for the variations of the coefficient's values from one inclusion measure to another. It also implies that saturation- and servicing-cost explanations should be considered as interpretations of estimates, not as directly observed causal processes.

The branch result shows nicely. Demographic branch density decreased and accounts and electronic payments grew, but there is a positive relationship between branch density geographically and efficiency. A possible reason is that rationalisation closed down some low-value outlets and left a network focused on those areas where advice, complicated transactions and customer service are still useful. It aligns with the joint focus on digitalisation and efficiency in FSMP Phase III (2016a) and the evidence that branches can be useful despite the increasing trend of routine transactions being moved online (Bernini and Brighi, 2018). The coefficient is still a medium correlation value, however. It can't decide if a certain branch should be opened, retained or closed at a bank.

Practical implication is to not just grow or shrink the branch network but to optimise it instead. Demand for location-level information, transaction mix and customer characteristics can aid banks in determining where they still need to offer a full-service branch and where it can be replaced by assisted-digital or agent-based services. The deposit-account result is related to this issue. In the supply side data Thailand already had high account ownership and more than one deposit account per adult. In such a setting, the number of raw accounts is not a good performance indicator. Results of active use, affordability, service quality and financial health offer more useful information. This aligns with Global Findex and Bank of Thailand's household surveys that focus on financial services usage and its ability to respond to customer needs (Bank of Thailand 2020; World Bank 2022).

Cards have the same measurement issue. The number of cards issued does not give us any idea of whether the card is used, if balances are revolving, how much interchange and interest income is accrued or if the relationship costs are being covered. This negative credit-card coefficient is thus compatible with several scenarios, such as low usage levels, fee waivers, cost of rewards and higher acquisition or fraud-management costs. The present data will not enable one to say which of these is most important. Future studies would benefit from including transaction values, active-card ratios, delinquency and fraud losses, and PromptPay and QR usage, which continues to influence Thai retail payments to a greater extent.

The "deposit finding" requires a rethinking. Retail funding is stable – during times of stress. A DEA production frontier, however, does not value the amount of a resource that is held as a hedge against future losses: it only values the amount of a resource that is used in producing the observed output. A bank in the short run can then seem less efficient, but more robust. This trade-off is particularly applicable to the situation of 2020-2021, when Thai banks were in a relatively good capital and liquidity position and started to provision more, as observed by the Bank of Thailand (2021b, 2022). The negative deposit coefficient should not be used as an

argument for weaker buffers. Efficiency must be understood in conjunction with other elements of stability, asset quality and service access.

Finally, it is the Thai evidence that helps to shed light on the relevance of the findings of past studies, which are not always shared. Increased bank performance is associated with increased stable funding when inclusion is increased (Ahamed et al., 2021), and increased financial efficiency is associated with decreased inclusion (Le et al., 2019). Both can be consistent with the existing structure. Finding a new customer for a service that has not yet been provided in formal finance could yield significant profits. If a product is added to a market already open, it might produce a lot less. The mix of those outcomes will depend on product usage and institutional development and the bank's capacity to put the extra money into use.

There is also a methodological aspect to it. It is not enough that a national inclusion indicator is added to all bank observations in the same year for this indicator to be considered as a bank-level indicator. In Thailand, the numbers in each inclusion series only change nine times. The ASEAN-6 interaction model takes into account country-year variation while clustering at the country-year level will not give unnaturally small SEs due to repeated national values. The study is still focussed on Thailand, but the larger sample is used for identification and frontier construction purposes, which does not alter the Thailand focus. The Maya Declaration and AFI membership are run on the same principle. They are considered as background institutions and are not the subject of a separate policy treatment, since their status does not change over the sample. A design appropriate for causal policy evaluation would be different and a credible date for treatment.

Bank managers should think about use and unit economics and not about product issuance. Active account ratios, transactions per customer, digital cost per transaction, branch-level transaction mix, fraud losses, average balances, cross-selling results and incremental deposit conversion to risk-adjusted earning assets would give a clearer indication of the productivity of including. The results are in line with the Bank of Thailand's ongoing investment in interoperable payments, consumer protection and financial education, with a greater focus on being active, affordable and high-quality. Bank of Thailand (2019, 2021a) has already integrated innovation and inclusion with resilience and information in the Fifth Payment System Roadmap (2019-2023) through the 5I framework. Although physical access is still a big deal, especially for those who require assisted service, the decision on branches should be based on service demands and connectivity, not an expansion target.

Measurement should follow the same logic. Counts of accounts, cards and access points describe the stock of financial access, but they say little about frequency of use or the value created. Transaction frequency, average balances, active-account ratios, digital usage, cost per customer and risk-adjusted income are closer to the idea of productive inclusion. Affordability and household financial resilience should also be considered. A negative coefficient on an access stock is not a reason to reduce the product mechanically. Accounts, deposits and payment instruments provide welfare, liquidity and stability benefits that are not fully captured by a production frontier. The relevant policy question is therefore how to make access useful and sustainable, not how to maximise DEA efficiency at the expense of access.

Advanced International Journal of Business, Entrepreneurship and SME's
AIJBES
EISSN: 2682-8545
Volume: 8 Issue: 29 (September 2026) PP. 2329-2351

Conclusion, Policy Implications and Future Research

The main DEA results can be summarised in three points. The annual mean scores over 2013-2021 are 0.599 for TE, 0.682 for PTE and 0.867 for SE. Of the 211 Thai bank-year observations, 138 operate under DRS, 45 under CRS and 28 under IRS. The gap is also larger for PTE than for SE, which indicates that management, operating processes and resource use account for more of the average inefficiency than scale adjustment. These results are obtained from a two-stage framework in which the ASEAN-6 sample is used for frontier construction and second-stage identification, while the interpretation remains centred on Thailand.

The second-stage results are not uniformly positive. ATM density is not statistically significant. Branches per 1,000 km^2 are positively associated with efficiency in the log model ($\beta = 0.508$, $p = 0.090$) and in the level-TE robustness model ($\beta = 0.354$, $p = 0.017$). Deposit accounts, credit cards and outstanding deposits remain negative in both specifications. In a mature access market, these estimates are consistent with the possibility that some additional products are lightly used, costly to service, or not matched by productive deployment of funds. Those mechanisms are not observed directly in the data, so the findings remain associative rather than causal. The practical emphasis is therefore on active use, network design and risk-adjusted intermediation rather than access counts alone.

Several limitations need to be kept in view. DEA is deterministic and is sensitive to the choice of inputs, outputs and reference set. The second-stage estimates are conditional associations, not causal effects, and the regional panel contains 54 country-year clusters. The data end in 2021 and do not include bank-level PromptPay transactions, active digital users, cybersecurity costs, branch locations, card activity, account dormancy or customer-level cost-to-serve. Future research could extend the sample beyond 2021, add bank-level digital and geospatial measures, and compare the present results with bootstrap or bias-corrected efficiency estimators and undesirable-output DEA.

Thailand's experience points to a distinction between access and productive use. A banking system can be highly inclusive and reasonably efficient, yet further expansion in the number of accounts, cards or access points may deliver smaller gains than earlier expansion. Once formal access is widespread, efficiency depends more on whether customers use the service, whether banks can deliver it at reasonable cost, and whether additional funding is converted into sustainable earning assets. For Thailand, the evidence therefore places more weight on customer activation, interoperable digital services, evidence-based network design and disciplined cost and risk management than on the simple growth of access counts.

Acknowledgements: The authors gratefully acknowledge Universiti Teknologi MARA (UiTM) for the institutional support, academic resources and research environment that contributed to the completion of this study.

Funding Statement: No Funding.

Conflict of Interest Statement: The authors declare that there is no conflict of interest regarding the publication of this paper.

Ethics Statement: This study did not involve human participants, animals, or sensitive data requiring ethical approval. The research used secondary institutional and macroeconomic data and was conducted in accordance with accepted academic integrity and ethical publishing standards.

Author Contribution Statement: All authors were responsible for conceptualisation, methodology, data compilation, analysis, interpretation of results, drafting and critical revision of the manuscript, and approved the final version for submission.

Data Availability Statement: Bank-level financial data are proprietary Fitch Connect data and cannot be redistributed. Financial-inclusion and macroeconomic variables are publicly available from the IMF Financial Access Survey and the World Development Indicators.

References

Alliance for Financial Inclusion (AFI). (2011). *Maya Declaration on Financial Inclusion Report 2011*. Alliance for Financial Inclusion.

Alliance for Financial Inclusion (AFI). (2025). *Maya Declaration Progress Report 2025.* Alliance for Financial Inclusion.

Ahamed, M. M., Ho, S. J., Mallick, S. K., & Matousek, R. (2021). Inclusive banking, financial regulation and bank performance: Cross-country evidence. *Journal of Banking & Finance*, 124, 106055.

Allen, F., Demirgüç-Kunt, A., Klapper, L., & Martínez Pería, M. S. (2016). The foundations of financial inclusion: Understanding ownership and use of formal accounts. *Journal of Financial Intermediation*, 27, 1–30.

Amidzic, G., Massara, A., & Mialou, A. (2014). Assessing countries' financial inclusion standing: A new composite index. *IMF Working Paper* WP/14/36.

Arora, R. U. (2010). *Measuring financial access*. Griffith Business School Discussion Paper No. 7.

Banna, H., Hassan, M. K., & Bataineh, H. (2023). Bank efficiency and fintech-based inclusive finance: Evidence from dual banking systems. *Journal of Islamic Monetary Economics and Finance*, 9(1), 1–28.

Bank of Thailand. (2016a). *Financial Sector Master Plan Phase III (2016–2020).* Bank of Thailand.

Bank of Thailand. (2016b). *Payment Systems Annual Report 2016.* Bank of Thailand.
Bank of Thailand. (2017). *Payment Systems Annual Report 2017*. Bank of Thailand.
Bank of Thailand. (2019). *Payment Systems Annual Report 2019*: The First Step of the Payment Systems Roadmap No. 4. Bank of Thailand.
Bank of Thailand. (2020). *Financial Access Survey of Thai Households 2020*. Bank of Thailand and National Statistical Office.
Bank of Thailand. (2021a). *Payment Systems Annual Report 2021*: Thai Payments and the Next Step into the Digital World. Bank of Thailand.
Bank of Thailand. (2021b). *Performance of the Thai Banking System in 2020*. BOT Press Release No. 10/2021.
Bank of Thailand. (2022). *Performance of the Thai Banking System in 2021*. BOT Press Release No. 9/2022.
Banker, R. D., Charnes, A., & Cooper, W. W. (1984). Some models for estimating technical and scale inefficiencies in data envelopment analysis. *Management Science*, 30(9), 1078–1092.
Beck, T., Demirgüç-Kunt, A., & Martínez Pería, M. S. (2007). Reaching out: Access to and use of banking services across countries. *Journal of Financial Economics*, 85(1), 234–266.
Berger, A. N., & Humphrey, D. B. (1997). Efficiency of financial institutions: International survey and directions for future research. *European Journal of Operational Research*, 98(2), 175–212.
Berger, A. N., & Mester, L. J. (1997). Inside the black box: What explains differences in the efficiencies of financial institutions? *Journal of Banking & Finance*, 21(7), 895–947.
Bernini, C., & Brighi, P. (2018). Bank branch expansion, efficiency and local economic growth. *Regional Studies,* 52(10), 1332–1345.
Buakes, S. (2023). An analysis of operational efficiency of Thai specialised financial institutions. *Songklanakarin Journal of Management Sciences*, 40(2), 1–25.
Bunpong, N., & Chancharat, N. (2012). An evaluation of commercial bank performance in Thailand by data envelopment analysis. *Songklanakarin Journal of Management Sciences*, 29(2), 1–22.
Casu, B., & Molyneux, P. (2003). A comparative study of efficiency in European banking. *Applied Economics,* 35(17), 1865–1876.
Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision-making units. *European Journal of Operational Research*, 2(6), 429–444.
Coelli, T. J., Rao, D. S. P., O'Donnell, C. J., & Battese, G. E. (2005). An Introduction to Efficiency and Productivity Analysis (2nd ed.). *Springer.*
Cull, R., Ehrbeck, T., & Holle, N. (2014). Financial inclusion and development: Recent impact evidence. *CGAP Focus Note* No. 92.
Demirgüç-Kunt, A., Klapper, L., Singer, D., & Ansar, S. (2022). The Global Findex Database 2021: *Financial Inclusion, Digital Payments, and Resilience in the Age of COVID-19.* World Bank.
DeYoung, R., Lang, W. W., & Nolle, D. L. (2007). How the Internet affects output and performance at community banks. *Journal of Banking & Finance,* 31(4), 1033–1060.
Diamond, D. W. (1984). Financial intermediation and delegated monitoring. *Review of Economic Studies*, 51(3), 393–414.
Emrouznejad, A., & Yang, G.-L. (2018). A survey and analysis of the first 40 years of scholarly literature in DEA: 1978–2016. Socio-Economic Planning Sciences, 61, 4–8.
Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society: Series A*, 120(3), 253–281.

Frączek, B. (2019). Main reasons and consequences of financial exclusion: A theoretical framework. *European Financial and Accounting Journal,* 14(1), 7–36.
Haq, M., Skully, M., & Pathan, S. (2010). Efficiency of microfinance institutions: A data envelopment analysis. *Asia-Pacific Financial Markets,* 17, 63–97.
International Monetary Fund. (2020). *Financial Access Survey*: 2020 Results. International Monetary Fund.
International Monetary Fund. (2022). *Financial Access Survey*: 2022 Results and 2021 Data. International Monetary Fund.
Kamarudin, F., Sufian, F., Loong, F. W., & Anwar, N. A. M. (2017). Assessing the domestic and foreign Islamic banks' efficiency: Insights from selected Southeast Asian countries. *Future Business Journal*, 3(1), 33–46.
Kim, D.-W., Yu, J.-S., & Hassan, M. K. (2018). Financial inclusion and economic growth in OIC countries. *Research in International Business and Finance*, 43, 1–14.
Le, T.-H., Chuc, A. T., & Taghizadeh-Hesary, F. (2019). Financial inclusion and its impact on financial efficiency and sustainability: Empirical evidence from Asia. *Borsa Istanbul Review*, 19(4), 310–322.
McDonald, J. (2009). Using least squares and Tobit in second-stage DEA efficiency analyses. *European Journal of Operational Research*, 197(2), 792–798.
Nguyen, D.-N., Mishra, A. V., & Daly, K. (2023). Variation in the competition–efficiency nexus: Evidence from emerging markets. *International Review of Economics & Finance*, 83, 401–420.
North, D. C. (1990). Institutions, Institutional Change and Economic Performance. *Cambridge University Press.*
Omar, M. A., & Inaba, K. (2020). Does financial inclusion reduce poverty and income inequality in developing countries? A panel data analysis. *Journal of Economic Structures*, 9, 37.
Ozili, P. K. (2018). Impact of digital finance on financial inclusion and stability. *Borsa Istanbul Review,* 18(4), 329–340.
Ozili, P. K. (2021). Financial inclusion and fintech during COVID-19 crisis: Policy solutions. *SSRN Electronic Journal.*
Papke, L. E., & Wooldridge, J. M. (1996). Econometric methods for fractional response variables with an application to 401(k) plan participation rates. *Journal of Applied Econometrics*, 11(6), 619–632.
Park, C.-Y., & Mercado, R. V. (2018). *Financial inclusion: New measurement and cross-country impact assessment*. ADB Economics Working Paper No. 539.
Sarma, M. (2008). *Index of financial inclusion.* ICRIER Working Paper No. 215.
Scott, W. R. (2014). *Institutions and Organizations: Ideas, Interests, and Identities* (4th ed.). Sage.
Sealey, C. W., & Lindley, J. T. (1977). Inputs, outputs, and a theory of production and cost at depository financial institutions. *Journal of Finance*, 32(4), 1251–1266.
Shukur, N., & Sufian, F. (2025). Unpacking the effects of financial inclusion on bank efficiency: A cross-country analysis of the ASEAN 5+1 banking sectors. Advanced International Journal of Business, Entrepreneurship and SMEs, 7(25), 699–719.
Simar, L., & Wilson, P. W. (2007). Estimation and inference in two-stage, semi-parametric models of production processes. *Journal of Econometrics*, 136(1), 31–64.
Suebpongsakorn, A., Khaekhai, C., Prakeetawathin, T., Rungpromprathan, W., & Saeing, S. (2016). A measurement of operational efficiency of commercial banks in Thailand by data envelopment analysis. *University of the Thai Chamber of Commerce Journal,* 36(3), 59–78.

Suddaby, R. (2010). Challenges for institutional theory. *Journal of Management Inquiry*, 19(1), 14–20.

White, H. (1980). A heteroskedasticity-consistent covariance matrix estimator and a direct test for heteroskedasticity. *Econometrica*, 48(4), 817–838.

World Bank. (2022). *Global Findex Database 2021*. World Bank.

Yadav, M., Sahu, T. N., & Maity, S. (2022). Financial inclusion and bank efficiency: Evidence from data envelopment analysis. *Colombo Business Journal*, 13(1), 141–169.