Islamic Banks' Bootstrap Efficiency and Its Determinants: Cross Country Evidence from Nine South and Southeast Asian Countries

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This paper employs bootstrap Data Envelopment Analysis (DEA) to first estimate the technical efficiencies under constant returns to scale (CRS) and variable returns to scale (VRS) for Islamic banks across nine South and Southeast Asian countries (Indonesia, Malaysia, Brunei, Singapore, Maldives, Thailand, Sri Lanka, Bangladesh, and Pakistan). The findings reveal that the average VRS technical efficiency for the region is 82.1%, which is higher than the CRS technical efficiency of 76.6%, indicating input wastage of 17.9% and 23.4%, respectively. A cross-country comparison shows that Malaysia's Islamic banks have the highest average CRS efficiency (80.1%) and VRS efficiency (87.2%) in the region, followed by Pakistan, Bangladesh, and Indonesia. In the second stage, using Simar and Wilson's (2007) truncated regression, the study identifies that bank capital risk (EQTA), bank credit risk (NPLL), and bank liquidity (CASTA) are significant internal factors negatively influencing both CRS and VRS technical efficiencies in loans and deposit production. Among external factors, the bank loan market structure (Herfindahl-Hirschman Index (HHI)), per capita GDP, and a country-specific dummy variable significantly and positively impact bank efficiencies. The significance of bank internal and country-specific factors has important policy implications for bank management.

Keywords: bootstrap DEA efficiency, determinant factors, Islamic banks, South and Southeast Asia

INTRODUCTION

The study of "Islamic Banks' Bootstrap Efficiency and Its Determinants: Cross-Country Evidence from Nine South and Southeast Asian Countries" is paramount due to the dynamic and heterogeneous nature of Islamic banking in this region. This research provides crucial insights for several reasons:

- **Growing Demand for Islamic Banking:** The nine countries—Bangladesh, Pakistan, Malaysia, Singapore, Indonesia, Brunei, Maldives, Thailand, and Sri Lanka—represent a region where Islamic banking is experiencing rapid growth. With an increasing demand for Shariah-compliant financial services driven by cultural and religious factors, understanding the efficiency of Islamic banks is essential. This study can inform policymakers and financial institutions about the effectiveness of Islamic banking operations in meeting this demand and contributing to financial inclusion.
- **Regulatory Diversity and Its Impact:** Islamic banking regulatory frameworks vary significantly across these countries, from highly developed systems like Malaysia's to emerging ones in Brunei and the Maldives. By analyzing the efficiency of Islamic banks across different regulatory environments, this study highlights the impact of regulatory structures on

bank performance. Understanding these differences can guide regulators in harmonizing policies to enhance the efficiency and stability of Islamic banks in the region.

- **Maturity and Developmental Stages:** The Islamic banking sectors in these countries are at different stages of maturity, with Malaysia leading as a global hub, while others like Thailand and Sri Lanka are still developing their markets. This study's cross-country analysis allows for a comparative understanding of Islamic banks' performance in varying economic and market conditions. Identifying the determinants of efficiency in both mature and emerging markets can provide valuable lessons for countries looking to develop or expand their Islamic banking sectors.
- **Economic and Market Structure Differences:** The diverse economic structures—from Singapore's advanced economy to Bangladesh's agriculture-driven economy—add complexity to studying Islamic banking efficiency. Considering these differences, the study contributes to a nuanced understanding of how economic factors influence Islamic banking performance across different contexts. This can help tailor strategies to improve efficiency in countries with varying economic conditions.
- **Financial Inclusion and Stability:** Islamic banking is crucial in promoting financial inclusion, particularly in countries with large unbanked populations, such as Pakistan and Bangladesh. Understanding the efficiency of Islamic banks is vital for ensuring that these institutions can sustainably expand their services to underserved communities. Additionally, the study can shed light on the stability of Islamic banks in different regulatory and economic environments, which is crucial for maintaining confidence in the financial system.
- **Contribution to the Literature:** Existing literature on Islamic banking efficiency often focuses on individual countries or specific regions, with limited cross-country comparisons. This study fills a critical gap by providing empirical evidence on the efficiency of Islamic banks across a diverse set of countries in South and Southeast Asia. It also identifies key determinants of efficiency, offering insights that can contribute to the broader academic discourse on Islamic banking and finance.
- **Policy Implications:** The findings of this study have significant policy implications. By understanding the factors that drive efficiency in Islamic banking, policymakers can design interventions to improve bank performance, enhance regulatory frameworks, and promote the sustainable growth of the Islamic finance sector. This is particularly important for countries in the region looking to position themselves as leaders in Islamic banking.

In summary, this study is crucial for advancing the understanding of Islamic banking efficiency in a region characterized by diverse regulatory environments, varying levels of market maturity, and different economic structures. Its findings will be instrumental in guiding policymakers, regulators, and financial institutions in optimizing the performance and growth of Islamic banks across South and Southeast Asia.

The paper is organized as: Key characteristic features of Islamic banks and the significant differences with the conventional banks are discussed in Section 2. Survey of the literature is provided in section 3. Section 4 describes data and the methodology of this paper. Empirical results are provided and discussed in Section 5. Policy prescriptions and conclusions are discussed in in Section 6 and Section 7 respectively.

ISLAMIC BANK VIS-À-VIS CONVENTION BANKS DIFFERENCES

The understanding operational module of the Islamic banks requires the knowledge of the key Characteristic Features of Islamic Banks: The following are the distinguishing features of the Islamic banks:

- **Shariah Compliance:** Islamic banks operate in accordance with Shariah (Islamic law), which prohibits interest (Riba), excessive uncertainty (Gharar), and investments in prohibited (Haram) industries such as alcohol, gambling, and pork-related products.
- **Profit and Loss Sharing (PLS):** Islamic banks emphasize equity-based financing models where profits and losses are shared between the bank and the customer. Common contracts

include Mudarabah (profit-sharing) and Musharakah (joint venture), where the bank invests in a business and shares the profits or losses.

- **Asset-Backed Financing:** Transactions in Islamic banking are backed by tangible assets or services. This ensures that money is tied to real economic activity, avoiding speculative practices. Examples include Ijara (leasing), Murabaha (cost-plus financing), and Istisna (construction financing).
- **Risk Sharing:** Islamic banks promote risk-sharing between the bank and its clients. This is in contrast to conventional banking, where the borrower bears the full risk of the investment. Risk-sharing aligns with the principles of fairness and justice in Islamic finance.
- **Zakat (Charity) and Social Responsibility:** Islamic banks may participate in collecting and distributing Zakat (obligatory charity) and are generally encouraged to contribute to social and charitable activities. This reflects the broader goal of Islamic finance to promote social justice and equity.
- **Shariah Supervisory Board:** Islamic banks have a Shariah Supervisory Board (SSB) comprising scholars who ensure that all products and services comply with Islamic law. This board reviews and approves financial contracts and operations to ensure Shariah compliance.

As these characteristics unique with the Islamic banks, there significant differences between Islamic and conventional Interest-Based Banks: The following are the areas of differences:

- **Prohibition of Interest (Riba) vs. Interest-Based Lending:** Islamic Banks: Riba, or interest, is strictly prohibited. Instead of charging or paying interest, Islamic banks earn profits through trade, investment, or leasing, where the returns are linked to actual economic activity. In conventional banks' case, the primary income source is interest charged on loans. Conventional banks lend money and earn interest, regardless of the outcome of the borrower's venture.
- **Profit and Loss Sharing vs. Fixed Returns:** Islamic Banks: Returns on investments are shared between the bank and its clients, depending on the outcome of the investment. This profit and loss-sharing mechanism aligns the interests of both parties. Conventional Banks: Lenders receive a predetermined interest rate, which remains the same regardless of the success or failure of the borrower's investment. The borrower bears all the financial risks.
- **Asset-Based Financing vs. Debt-Based Financing: Islamic Banks:** All transactions must be backed by tangible assets or services. Islamic finance encourages asset-based financing, exchanging money for goods or services, fostering a direct link between financial transactions and real economic activity. Conventional Banks: Conventional banks predominantly engage in debt-based financing, where loans are provided based on the borrower's creditworthiness rather than any underlying asset.
- **Ethical and Social Considerations vs. Profit Maximization:** Islamic Banks: Operations are guided by ethical principles and social responsibility. Investments are screened for compliance with ethical standards, and banks are encouraged to support community welfare and social justice. Conventional Banks: The primary focus is on maximizing shareholder value and profitability, often with fewer restrictions on the types of investments they can make, provided they comply with legal regulations.
- **Risk Sharing vs. Risk Transfer:** Islamic Banks: Emphasize risk-sharing mechanisms, where the risks are distributed between the bank and the customer. This encourages responsible financing and mutual accountability. Conventional Banks: Typically transfer risk to the borrower through fixed interest obligations, with the bank's risk primarily mitigated through collateral requirements and credit evaluations.
- **Shariah Compliance and Supervision vs. Regulatory Compliance:** Islamic Banks: Must comply with Shariah principles, overseen by a Shariah Supervisory Board that ensures all products and practices align with Islamic law. Conventional Banks: Operate under the regulatory framework of the country they are in, with no specific religious guidelines. Financial

regulators govern their operations focused on stability, consumer protection, and legal compliance.

- **No Speculative Practices vs. Acceptance of Speculation: Islamic Banks:** Speculation (Maysir) is prohibited. Islamic banks avoid speculative transactions and derivatives that do not involve real economic activity. Conventional Banks: Engage in speculative trading, derivatives, and other financial instruments that may involve high levels of risk, often without underlying assets.

Conclusion: Islamic banking offers an alternative financial system grounded in ethical and socially responsible principles, distinct from conventional banking's profit-maximization and interest-based framework. These differences underscore the unique value proposition of Islamic banks, particularly in regions with significant Muslim populations or where ethical finance is gaining traction.

SURVEY OF LITERATURE

The literature on the efficiency of Islamic banks can be broadly categorized into three areas: (A) studies focusing on the efficiency of Islamic banks, (B) studies analyzing the determinants of conventional bank efficiencies, and (C) studies investigating the determinants of Islamic bank efficiencies. Since this paper centers on the determinants of efficiency, the literature review will focus primarily on studies that explore the factors influencing the efficiency of Islamic banks while also acknowledging relevant contributions from research on conventional banking systems.

The Efficiency of Islamic Banks

Key studies examining the efficiency of Islamic banks include works by Noor and Ahmad (2012), Srairi and Kouki (2012), Rahman and Rosman (2013), Rosman et al. (2014), Hassine and Limani (2014), Bahrini (2016), and Samad (2013 A, 2013 B, 2017 C). These studies represent significant strides in understanding efficiency in Islamic banking and use various analytical methods to assess technical, scale, and pure technical efficiency across different regions and periods.

- Noor and Ahmad (2012) employed Data Envelopment Analysis (DEA) to assess the efficiency of 78 Islamic banks across 25 countries from 1992 to 2009. Their results indicated that technical efficiency improved during and after the global financial crisis, suggesting increased confidence in Islamic banks relative to conventional ones. Pure technical efficiency scores were higher than scale efficiency scores, which contrasted with earlier findings by Sufian and Noor (2009) and Yudistira (2004).
- Srairi and Kouki (2012) conducted a similar analysis using DEA on 25 Islamic banks in GCC countries from 2003-2009. They found that overall technical inefficiency stemmed mainly from pure technical inefficiency (29.3%) rather than scale inefficiency (17%), with an observed improvement in efficiency during and after the financial crisis.
- Rahman and Rosman (2013) and Rosman et al. (2014) compared the technical efficiency of Islamic banks in the Middle East and Asia between 2007-2010, reporting divergent trends: while Middle Eastern banks experienced a decline in efficiency, Asian banks showed improvement.
- Hassine and Limani (2014) analyzed 22 MENA Islamic banks from 2005-2009 and identified pure technical inefficiency as the main contributor to overall inefficiency, a consistent finding across multiple regions.
- Bahrini (2016) applied DEA and bootstrap DEA to examine the performance of 33 MENA Islamic banks during and after the global financial crisis, discovering that pure technical inefficiency (17.9%) outweighed scale inefficiency (9.1%).
- Samad (2013) explored the efficiency of Islamic banks in 16 countries using a time-varying Stochastic Frontier function, finding minimal differences between pre- and post-global

financial crisis periods. With mean efficiency scores of 39% and 38%, respectively, Samad's findings suggest stability in Islamic banking during the crisis.

- In another study, Samad (2013) compared the technical efficiency of Islamic and conventional banks in Bangladesh, focusing on loan financing and deposit mobilization. No significant differences were found between the two, with mean efficiency scores of 59.6% and 62.8% for loans and around 0.61 for deposits.
- Samad (2017) extended his research to Malaysian Islamic banks (2008-2012), highlighting higher efficiency in deposit mobilization than loan financing, with technical efficiency scores ranging from 83% to 97% for loans and 87% to 96% for deposits. However, many banks operated below optimal production scale, indicating room for improvement.

Determinants of Conventional Bank Efficiency

Numerous studies have also explored the factors influencing conventional bank efficiency, providing a comparative framework for understanding Islamic banking.

- Zelenyuk (2015), using bootstrap DEA and truncated regression to study Ukrainian banks, identified foreign ownership and equity capital as significant positive contributors to efficiency.
- Delis and Papanikolaou (2009) employed a semi-parametric two-stage model to analyze bank efficiency in newly acceded European countries, pinpointing bank size, industry concentration, and economic investment as critical factors.
- Repkovia (2015) studied Czech banks (2001-2013), discovering that capitalization, liquidity risk, and portfolio risk positively affected efficiency, while ROA, interest rates, and GDP had negative impacts.
- Pancurova and Lyocsa (2013) investigated bank efficiencies in 11 Central and Eastern European countries (2005-2018), identifying bank size, capitalization, and foreign ownership as positive factors, while the loan-to-asset ratio had mixed effects.
- Garza-Garcia (2012) examined Mexican banks (2001-2009) and found that loan intensity, GDP growth, and foreign ownership were positively correlated with efficiency.
- Widiarti, Siregar, and Andati (2015) studied Indonesian banks (2012-2014), concluding that non-performing loans, loan-deposit ratio, bank size, capital adequacy, and cost-efficiency ratio significantly affected efficiency.

Determinants of Islamic Bank Efficiency

While fewer in number, studies focusing on the determinants of Islamic bank efficiency offer valuable insights.

- Nafla and Hammas (2016) compared Islamic and conventional banks in eight countries, discovering that asset quality positively impacted Islamic banks during the global financial crisis.
- Ftiti, Nafti, and Sreiri (2013) used DEA and regression analysis to study the efficiency of GCC Islamic banks during the 2008 subprime crisis, finding that Islamic banks maintained efficiency throughout.
- Assaf et al. (2011) applied a two-stage DEA approach to analyze the efficiency of Saudi banks, concluding that ROA and liquidity were significant positive factors.
- Ahmad et al. (2015) employed a DEA double bootstrap technique to study Pakistani banks, revealing that bank liabilities negatively affected efficiency, while private ownership was a positive factor.
- Sardar et al. (2011) used DEA and Tobit regression to analyze 18 Islamic banks in Pakistan, finding that bank assets and profits positively influenced efficiency.

Conclusion

This literature review highlights a growing body of research on the efficiency of Islamic banks but reveals a notable gap in the study of South and Southeast Asian countries such as Indonesia, Malaysia, Brunei, Singapore, Maldives, Thailand, Bangladesh, Sri Lanka, and Pakistan. This study aims to bridge this gap by offering a pioneering analysis of the efficiency determinants of Islamic banks in these regions, contributing to the broader understanding of Islamic banking dynamics.

DATA AND METHODOLOGY

Data

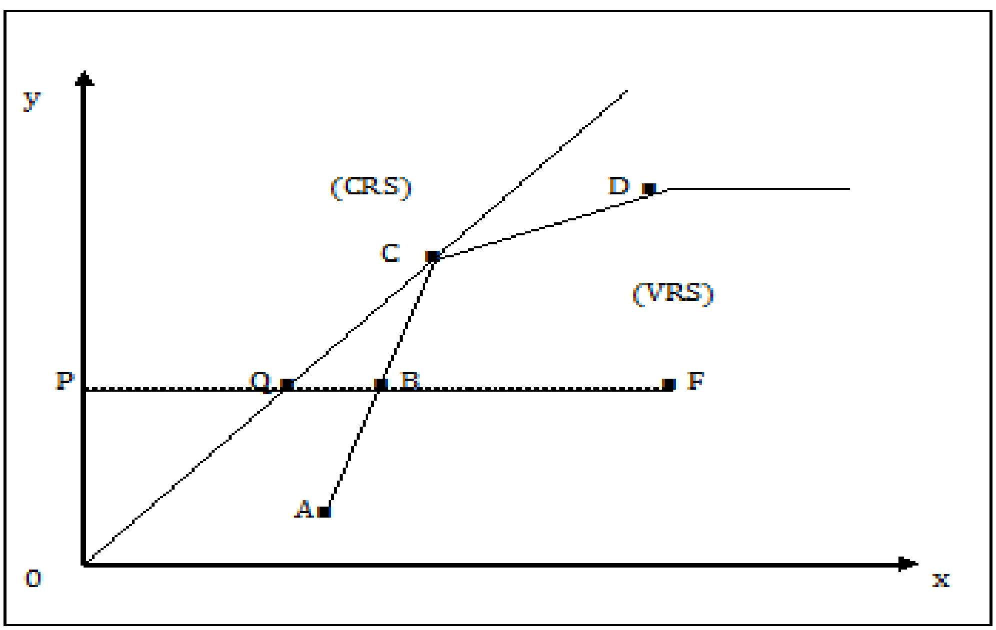
The study utilizes panel data from 2011 to 2016 for Islamic banks across several South and Southeast Asian countries. The dataset includes 9 Islamic banks from Bangladesh, 8 from Indonesia, 17 from Malaysia, 2 from Brunei, 4 from Pakistan, and 1 each from Singapore, Maldives, Thailand, and Sri Lanka. The data covers key bank inputs—such as fixed capital, employee wages, and deposits—and outputs—such as earning assets and gross loans. All values are expressed in U.S. dollars (in thousands) and were sourced from Bank Scope.

Methodology

Two primary approaches are commonly employed to measure bank efficiency: the **Stochastic Frontier Analysis (SFA)** and **Data Envelopment Analysis (DEA)**. DEA, which will be the focus of this study, has two distinct models. The first is the **CCR model** (Charnes, Cooper, and Rhodes, 1978), which assumes constant returns to scale (CRS) in evaluating the efficiency of Decision-Making Units (DMUs). The second model, known as the **BCC model** (Banker, Charnes, and Cooper, 1984), allows for variable returns to scale (VRS), accommodating increasing, constant, or decreasing returns to scale. The distinction between these models can be visualized in the efficiency frontier, where the CRS frontier measures overall technical efficiency, while the VRS frontier isolates pure technical efficiency, separating it from scale efficiency.

Figure 1 illustrates this difference between CRS and VRS frontiers:

FIGURE 1
CRS AND VRS EFFICIENCY FRONTIERS



Coelli et al., 2005

The line through the points Q and C represents the CRS efficiency frontier and the curve (ABCD) represents the VRS efficiency frontier. Each DMU that is on the frontier is technically efficient. For this reason, the particular DMU "F" is technically inefficient. When we refer to the CRS frontier, the distance FQ measures the technical inefficiency of the DMU "F". However, when we consider the VRS frontier, the technical inefficiency of the DMU "F" is only the distance FB. The difference between the CRS and the VRS frontiers is the distance QB, which measures scale inefficiency.

The overall technical efficiency score (under the CRS frontier): TE_{CRS} = PQ/PF
The pure technical efficiency score (under VRS frontier): TE_{VRS} = PB/PF
The scale efficiency score: SE = PQ/PB

In this study, I employ **Bootstrap-DEA** instead of the conventional DEA to correct for the limitations of the DEA method. Simar and Wilson (1998) state that the traditional DEA has notable shortcomings. First, it is a deterministic method, meaning it does not account for random errors, such as equipment malfunctions or power outages, which can cause efficiency overestimation. Second, the DEA method lacks statistical properties—such as confidence intervals—because the efficiency scores generated are deterministic and not probabilistic estimates.

Bootstrap, a simulation-based approach introduced by Efron (1979), addresses these issues by repeatedly resampling the data to mimic the data-generating process (DGP). As the resampled datasets approximate the original, the bootstrapped sampling distributions of means and standard deviations closely reflect the true values. The **Bootstrap-DEA** method, as pioneered by Simar and Wilson (1998), generates numerous replicated samples from the original dataset, allowing for the estimation of **bias-corrected efficiency scores** and confidence intervals at a chosen significance level (α).

Bootstrap-DEA provides more reliable and statistically sound efficiency estimates, enhancing the robustness of our findings compared to the traditional DEA approach.

Empirically, an estimate of the radial Debreu-Farrell output-based measure of technical efficiency can be calculated and obtained by solving a linear programming problem for each data point k (k=1, . . ., K):

$$\hat{F}_k^0(Y_k, X_k, Y, X|CRS) = \max_{\theta, Z} \theta \tag{1}$$

$$\text{s.t.} \quad \sum_{k=1}^{K} z_k Y_{km} \geq Y_{km}\theta_m,\ m = 1, \ldots, M$$
$$\sum_{k=1}^{K} z_k X_{kn} \leq X_{kn},\ n = 1, \ldots, N$$
$$Z_K \geq 0$$

where Y is K x M matrix of available outputs, X is K x N matrix of available inputs. CRS specifies constant returns to scale. For variables to scale (VRS) a convexity constraint $\sum_{k=1}^{K} Z_k = 1$

θ Is a scalar and represents the efficiency score of each decision-making unit (DMU). The range of ≤θ≤1, with a value of 1 indicating a point on the frontier and hence a technically efficient DMU, i.e. output of the DMU cannot be increased without increasing inputs. A DMU is inefficient when the value of θ<1; that is, a given output can be produced by reducing inputs of the DMU.

Bias is calculated as follows:

$$\text{Bias}(\hat{\theta}_k) = E(\hat{\theta}_k) - \hat{\theta}_k.$$

$$\text{Bias}(\hat{\theta}_k) = B^{-1\sum_{k=1}^{K}(\hat{\theta}*_k)} - \hat{\theta}_k.$$

The bias-corrected efficiency score can be expressed as:

$$\tilde{\theta}_k = \hat{\theta}_k - \text{bias}(\hat{\theta}_k) = 2\,\hat{\theta}_k - B^{-1\sum_{k=1}^{K}(\hat{\theta}*_k)}.$$

Input-Output Controversy and Model Selection

In production processes such as coal mining, identifying inputs and outputs is straightforward. The output is the quantity of coal, and the inputs are labor and capital. However, in multiproduct firms like banks, which offer a range of services and use various inputs, determining which elements are inputs and outputs has been a long-standing debate. The question of what constitutes a bank's inputs and outputs has been controversial for years.

According to the production approach (Benston, 1965), a bank is seen as a provider of services for account holders, producing deposit accounts and loan services using labor and capital. From this perspective, the number of deposit accounts or total deposits can be considered outputs. The interest income paid to depositors plays a crucial role in mobilizing total deposits.

On the other hand, the intermediation approach, first proposed by Sealey and Lindley (1977), views a bank as a financial intermediary. It collects deposits from savers and channels these funds to borrowers, treating earning assets as outputs and deposits as inputs. In this framework, loans, investments in securities, and advances are considered outputs, while labor, capital, deposits, and their associated expenses are classified as inputs.

Using the Sealey and Lindley (1977) framework, this study estimates two models employing the bootstrap Data Envelopment Analysis (DEA):

Model 1:

$$\text{loan}_i = \beta_0 + \beta_1 \text{ Fixed capital } + \beta_2\text{salay} + \beta_3\text{Deposit} \qquad (2)$$

Model 2:

$$\text{Deposit}_i = \beta_0 + \beta_1 \text{ fixed capital} + \beta_2\text{salay} \qquad (3)$$

In these models:

- Loan_i refers to total loans and earning assets, considered as outputs.

Descriptive statistics for the inputs and outputs in Models 1 and 2, used in estimating the efficiency of Islamic banks across nine South and Southeast Asian countries, are provided in Table 1.

TABLE 1
DESCRIPTIVE STATISTICS OF TWO INPUTS AND TWO OUTPUTS

	Inputs			Outputs	
	WAGE	FIXCAP	DEPOSIT	EARNINGASST	GROSSLOANS
Mean	28508.06	28557.66	2919471.	3467526.	2471306.
Median	13369.00	8695.500	1387491.	1821007.	1370420.
Maximum	190534.0	275378.0	20490804	25319612	18558484
Minimum	140.0000	4.000000	43.00000	6140.000	2784.000
Std. Dev.	39610.02	47267.66	3792588.	4619461.	3237659.
Observations	271	272	272	272	271

*=all values are in constant $ (million)

In Table 1, two outputs were: gross loans and earning assets. Three inputs were: employee wages, bank fixed capital, and deposits. They used to product output.

Two inputs, employee wages and bank fixed capital were used to produce deposit. All values were in million dollars.

After estimating the efficiency of each bank using the bootstrap DEA method, this study applied the Simar and Wilson (2000) truncated regression to identify the significant factors influencing bank efficiency or inefficiency. Simar and Wilson argue that the traditional two-stage DEA with Tobit regression is flawed. They emphasize that (i) the efficiency score from the basic DEA is a relative measure, not an absolute value, and (ii) efficiency scores tend to be correlated, violating the ordinary least squares (OLS) assumption of uncorrelated dependent variables.

The following truncated maximum likelihood regression model is estimated:

$$\theta_{vrs} = \alpha + \beta Z_j + \varepsilon \tag{4}$$

In equation (4), a is the constant term, ε_i is a random error term, identically and independently distributed, and Zi is a set of explanatory variables for bank i which is hypothesized to impact on the bias-corrected efficiency score (θ_i) determining efficiencies of the banks. β is a vector of parameters to be estimated

Description of Z Variables

This study classifies the explanatory variables, Z, into three categories:

A. **Bank-specific variables:** (i) bank capital risk, (ii) bank credit risk, and (iii) bank liquidity risk.
B. **Market structure and macroeconomic variables:** (i) the Herfindahl-Hirschman Index for deposits (HHID), (ii) the Herfindahl-Hirschman Index for loans (HHIL), and (iii) per capita GDP (GDPp).
C. **Expanded model:** Combines categories A and B with country-specific dummy variables (DUMi), where DUMi=1 for each of the nine South and Southeast Asian countries and 0 otherwise. The countries are Indonesia (INDO), Malaysia (MAL), Bangladesh (BANG), Pakistan (PAK), Brunei (BRUN), Singapore (SING), Sri Lanka (SRI), and Thailand (THAI).

Bank capital risk is measured by the equity-to-assets ratio (EQTA), credit risk is measured by the non-performing loan ratio (NPLL), and liquidity risk is represented by the cash-to-assets ratio (CASTA). Descriptions of these factors and their hypothesized relationships with bank efficiency are summarized in Table 2.

Where bank capital risk is measured by EQTA= total equity capital as percentage of total assets, the bank credit risk is measured by NPLL = non-performance loan as percentage of gross loans, and the bank liquidity risk is measured by CASTA= total cash in bank vaults and with other banks as percentage of total assets.

The descriptions of factors incorporated in Z and the hypothesized relation with bank efficiency is presented in Table 3.

Using the set of explanatories (Z) variables, this paper applied the Simar and Wilson truncated regression for determining the efficiency/inefficiency factors of the Islamic banks. The estimated models are:

$$\text{Loans } \theta_{vrs} = \alpha + \beta_1 EQTA + \beta_2 NPLL + \beta_3 CASTA$$
$$\text{Loans } \theta_{CRS} = \alpha + \beta_1 EQTA + \beta_2 NPLL + \beta_3 CASTA \tag{5}$$

$$\text{Deposit } \theta_{vrs} = \alpha + \beta_1 HHI_L + \beta_2 HHI_D + \beta_3 GDP_P \tag{6}$$

$$\text{Deposit } \theta_{CRS} = \alpha + \beta_1 HHI_L + \beta_2 HHI_D + \beta_3 GDP_P \tag{7}$$

$$\text{Loans } \theta_{vrs} = \alpha + \beta_1 EQTA + \beta_2 NPLTA + \beta_3 CASTA + \beta_4 HHI_L + \beta_5 HHI_D + \beta_6 GDP_P + \beta_7 INDO + \beta_8 MAL + \beta_9 BANG + \beta_{10} PAK + \beta_{11} BRUN + \beta_{12} SING + \beta_{13} SRI + \beta_{14} THAI \tag{8}$$

$$\text{Loans } \theta_{crs} = \alpha + \beta_1 EQTA + \beta_2 NPLTA + \beta_3 CASTA + \beta_4 HHI_L + \beta_5 HHI_D + \beta_6 GDP_P + \beta_7 INDO + \beta_8 MAL + \beta_9 BANG + \beta_{10} PAK + \beta_{11} BRUN + \beta_{12} SING + \beta_{13} SRI + \beta_{14} THAI \tag{9}$$

Deposit $\theta_{vrs} = \alpha + \beta_1 EQTA + \beta_2\, NPLTA + \beta_3 CASTA + \beta_4 HHI_L + \beta_5\, HHI_D + \beta_6 GDP_P + \beta_7 INDO + \beta_8 MAL + \beta_9\, BANG + \beta_{10} PAK + \beta_{11} BRUN + \beta_{12} SING + \beta_{13} SRI + \beta_{14} THAI$ (10)

Deposit$\theta_{crs} = \alpha + \beta_1 EQTA + \beta_2\, NPLTA + \beta_3 CASTA + \beta_4 HHI_L + \beta_5\, HHI_D + \beta_6 GDP_P + \beta_7 INDO + \beta_8 MAL + \beta_9\, BANG + \beta_{10} PAK + \beta_{11} BRUN + \beta_{12} SING + \beta_{13} SRI + \beta_{14} THAI$ (11)

The hypothesized relationship between the efficiency score and the set of explanatory variables is described in Table 2

TABLE 2
HYPOTHESIZED RELATIONSHIP BETWEEN EFFICIENCY SCORE AND EXPLANATORY VARIABLES

Variable	Hypothesized relation	Explanation
$\frac{\partial\theta}{\partial EQTA}$	(+) or (-)	Bank with a more equity capital is likely to be less vulnerable to capital risk and may attract more deposits and can become more efficient. On the other, a bank with more equity capital in hand is likely to lose the opportunity of making more loans and thus may become less efficient in loan financing.
$\frac{\partial\theta}{\partial NPLL}$	(-)	Bank credit risk increase with NPLL and it decreases bank efficiency.
$\frac{\partial\theta}{\partial CASTA}$	(+) or (-)	A bank with less cash in hand faces high liquidity risk and it may affect bank efficiency negatively. On the other hand, a bank with less cash in asset portfolio indicates that it generates more loans and earning assets and thus, more efficient in loan production.
$\frac{\partial\theta}{\partial HHIL}$	(+) or (-)	HHIL index provides the competitiveness of bank market structure in loan market. The higher bank competition may increase bank efficiency or decrease bank efficiency.
$\frac{\partial\theta}{\partial HHID}$	(+) or (-)	HHIL index provides the competitiveness of bank market structure in loan market. The higher bank competition may increase bank efficiency or decrease bank efficiency
$\frac{\partial\theta}{\partial GDPP}$	(+)	Bank loan financing and deposit mobilization increase with the increase in per capita GDP growth which help improving bank efficiency
$\frac{\partial\theta}{\partial DUMi}$	(+)	Country dummy variable, DUM_i, such as pro-bank public attitude, less corruption, positive government support, it is expected DMU_i to have positive impact on bank efficiency.

Empirical Results

The Bootstrap DEA technical efficiency scores for Islamic banks in Indonesia, Malaysia, Brunei, Singapore, Maldives, Thailand, Sri Lanka, Bangladesh, and Pakistan, based on loan and deposit production under Constant Returns to Scale (CRS) and Decreasing Returns to Scale (DRS), are displayed in Tables 3, 4, 5, and 6.

TABLE 3
CONSTANT RETURN TO SCALE (CRS) TECHNICAL EFFICIENCY (TE), BIAS-CORRECTED TECHNICAL EFFICIENCY (TEBC), BIAS, AND 95 % CONFIDENCE INTERVAL ESTIMATE OF PRODUCTION FOR LOANS AND EARNING ASSETS DURING 2011-2016

Country	Average	te1	te1bc	telbias	te1lower	te1upper
Malaysia	Average	0.828	0.801	0.027	0.777	0.824
Indonesia	Average	0.748	0.732	0.016	0.717	0.745
Brunei	average	0.762	0.753	0.008	0.742	0.760
Maldives	Average	0.777	0.769	0.009	0.757	0.776
Bangladesh	Average	0.772	0.757	0.014	0.744	0.768
Pakistan	Average	0.784	0.755	0.029	0.739	0.778
Thailand	average	0.767	0.755	0.012	0.742	0.764
Singapore	average	0.936	0.801	0.135	0.758	0.920
Sri Lanka	average	0.788	0.771	0.017	0.754	0.784
Average of all countries		**0.796**	**0.766**	**0.030**	**0.748**	**0.791**

Explanation of Table 3

Table 3 presents the technical efficiency (TE), bias-corrected technical efficiency (TEBC), bias, and the 95% confidence interval estimates of production for loans and earning assets under the assumption of Constant Returns to Scale (CRS) for Islamic banks across several countries during the period from 2011 to 2016. The table includes data from Malaysia, Indonesia, Brunei, Maldives, Bangladesh, Pakistan, Thailand, Singapore, and Sri Lanka, along with an overall average for all countries.

- TE (Technical Efficiency): This column reports the average technical efficiency score of each country. A score closer to 1 indicates higher efficiency in converting inputs (such as deposits) into outputs (such as loans and earning assets). Singapore has the highest uncorrected technical efficiency at 0.936, while Indonesia shows the lowest at 0.748.
- TEBC (Bias-Corrected Technical Efficiency): This column presents the technical efficiency scores after adjusting for statistical bias using a bootstrapping method. The bias-corrected scores are slightly lower for most countries. For instance, Malaysia's TEBC is 0.801, compared to its uncorrected TE of 0.828. This adjustment aims to provide a more accurate efficiency estimate.
- Bias: This column indicates the degree of bias in the original technical efficiency score before correction. A higher bias indicates a larger difference between the raw and corrected scores. Singapore has the largest bias at 0.135, while Brunei has the smallest at 0.008.
- TE Lower and TE Upper (95% Confidence Interval): These two columns show the lower and upper bounds of the 95% confidence interval for the bias-corrected technical efficiency scores. For example, Malaysia's TEBC is estimated to lie between 0.777 and 0.824 with 95% confidence. These intervals help provide a range of likely values for the corrected efficiency score.

- Average of All Countries: The overall average technical efficiency for the entire sample of countries is 0.796, while the average bias-corrected efficiency is 0.766. The average bias across all countries is 0.030, and the 95% confidence interval for the bias-corrected efficiency ranges from 0.748 to 0.791.

In summary, Singapore shows the highest uncorrected technical efficiency and the largest bias, while countries like Brunei and Maldives exhibit more stable efficiency scores with minimal bias. The bias-corrected scores provide a more accurate reflection of the banks' operational efficiency in producing loans and earning assets across these Islamic banks.

TABLE 4
VARIABLE RETURNS TO SCALE (VRS) TECHNICAL EFFICIENCY (TE), BIAS-CORRECTED TECHNICAL EFFICIENCY (TEBC), BIAS, AND 95 % CONFIDENCE INTERVAL ESTIMATE OF PRODUCTION FOR LOANS AND EARNING ASSETS DURING 2011-2016

Country	Average	te1	te1bc	telbias	te1lower	te1upper
Malaysia	Average	0.908	0.872	0.035	0.842	0.903
Indonesia	Average	0.797	0.781	0.016	0.767	0.793
Brunei	average	0.868	0.854	0.013	0.841	0.864
Maldives	Average	0.782	0.761	0.021	0.740	0.779
Bangladesh	Average	0.829	0.815	0.015	0.801	0.826
Pakistan	Average	0.812	0.783	0.029	0.758	0.808
Thailand	average	0.866	0.854	0.011	0.842	0.863
Singapore	average	0.957	0.866	0.091	0.804	0.951
Sri Lanka	average	0.815	0.800	0.015	0.788	0.810
Average of all countries		**0.848**	**0.821**	**0.027**	**0.798**	**0.844**

Explanation of Table 4

Table 4 presents the technical efficiency (TE), bias-corrected technical efficiency (TEBC), bias, and 95% confidence interval estimates of production for loans and earning assets in Islamic banks across different countries from 2011 to 2016. This analysis uses the Variable Returns to Scale (VRS) assumption, allowing banks to operate at different scales of efficiency.

- TE (Technical Efficiency): This column shows the average efficiency score for each country’s Islamic banks under VRS. A score closer to 1 indicates higher efficiency in converting inputs into outputs. Singapore's banks display the highest efficiency at 0.957, followed by Malaysia at 0.908, while Indonesia’s efficiency is the lowest at 0.797.
- TEBC (Bias-Corrected Technical Efficiency): After correcting for bias using a bootstrapping method, the technical efficiency scores are slightly reduced in most cases. For example, Malaysia’s bias-corrected efficiency is 0.872, down from an uncorrected score of 0.908. The bias-corrected scores are considered more accurate.
- Bias: This column measures the degree of bias in the original TE scores. Higher bias indicates a greater difference between the raw and corrected efficiency values. Singapore's banks exhibit the highest bias at 0.091, while Thailand shows the smallest bias at 0.011, indicating that Thailand’s efficiency scores are more stable.
- TE Lower and TE Upper (95% Confidence Interval): These columns provide the range within which the bias-corrected efficiency score is likely to fall, with 95% confidence. For example,

the bias-corrected efficiency of Malaysia's banks is estimated to lie between 0.842 and 0.903. Singapore has a wider confidence interval, reflecting more uncertainty due to its higher bias.

- Average of All Countries: The overall average technical efficiency across all countries is 0.848, while the bias-corrected average is 0.821. The average bias across all countries is 0.027, which suggests that the initial TE scores slightly overstate efficiency.

Key Observations

1. **Malaysia's High Efficiency:** Malaysia's Islamic banks show the highest bias-corrected efficiency at 87.2%, making them the most efficient in the region. This result aligns with Malaysia's leading role in the development of Islamic banking systems.
2. **Regional Comparisons:** Other countries like Brunei, Thailand, and Singapore also demonstrate relatively high technical efficiency. However, Singapore's bias (0.091) suggests that its raw TE score may overstate its efficiency.
3. **Average Efficiency:** The regional average technical efficiency is 82.1%, indicating that, on average, Islamic banks in the region waste about 18.9% of their inputs. Malaysia outperforms this average with a lower input wastage of 12.8%, highlighting its more efficient use of resources.
4. **Bias Impact:** The overall bias across the sample is minimal (2.7%), but countries like Singapore display higher bias, which should be factored into performance assessments.

In summary, while Malaysia leads the region in terms of efficiency, the data shows some variability across countries, with bias correction providing a more accurate measure of technical efficiency for Islamic banks operating under variable returns to scale.

TABLE 5
CONSTANT RETURNS TO SCALE TECHNICAL EFFICIENCY (TE), BIAS-CORRECTED TECHNICAL EFFICIENCY (TEBC), BIAS, AND 95 % CONFIDENCE INTERVAL ESTIMATE OF DEPOSIT PRODUCTION DURING 2011-2016

Country	Average	te1	te1bc	telbias	te1lower	te1upper
Malaysia	Average	0.772	0.743	0.029	0.712	0.769
Indonesia	Average	0.683	0.674	0.009	0.656	0.683
Brunei	average	0.699	0.694	0.005	0.680	0.699
Maldives	Average	0.749	0.740	0.009	0.720	0.749
Bangladesh	Average	0.716	0.710	0.006	0.695	0.715
Pakistan	Average	0.673	0.664	0.009	0.650	0.672
Thailand	average	0.708	0.702	0.006	0.688	0.708
Singapore	average	0.337	0.307	0.030	0.290	0.335
Sri Lanka	average	0.710	0.694	0.015	0.670	0.709
Average of all countries		**0.672**	**0.659**	**0.013**	**0.640**	**0.671**

Explanation of Table 5

Table 5 shows the Constant Returns to Scale (CRS) technical efficiency (TE), bias-corrected technical efficiency (TEBC), bias, and 95% confidence interval estimates for deposit production in Islamic banks across various countries from 2011 to 2016.

- TE (Technical Efficiency): This column represents Islamic banks' average technical efficiency scores under the CRS assumption. A score closer to 1 indicates higher efficiency in converting inputs into deposits. For instance, Malaysia's banks have an average efficiency of 0.772, while Singapore's banks have a notably lower average efficiency of 0.337.

- TEBC (Bias-Corrected Technical Efficiency): These scores, which are adjusted for bias, provide a more accurate measure of technical efficiency. For example, Malaysia's bias-corrected efficiency is 0.743, slightly lower than the uncorrected score of 0.772.
- Bias: This column measures the difference between the raw TE scores and the bias-corrected TEBC scores. Higher bias indicates a greater discrepancy. Singapore shows the highest bias at 0.030, suggesting a significant difference between the raw and corrected efficiency values.
- TE Lower and TE Upper (95% Confidence Interval): These columns provide the range within which the bias-corrected efficiency score is expected to fall with 95% confidence. For Malaysia, the bias-corrected efficiency is expected to be between 0.712 and 0.769.
- Average of All Countries: The overall average technical efficiency for all countries is 0.672, with a bias-corrected average of 0.659. The average bias across the sample is 0.013, indicating a relatively small adjustment needed from the raw scores to the corrected values.

Key Observations

1. Singapore's Low Efficiency: Singapore's banks have the lowest average technical efficiency (0.337) and the highest bias (0.030), suggesting substantial overstatement in their raw efficiency scores. This result highlights potential inefficiencies in deposit production compared to other countries.
2. Regional Comparisons: Malaysia shows the highest average technical efficiency in deposit production among the countries listed, with a bias-corrected efficiency of 0.743. This indicates relatively better performance in converting inputs into deposits compared to the regional average.
3. Average Efficiency: The regional average technical efficiency is 0.672, implying that, on average, Islamic banks waste about 32.8% of their potential efficiency in deposit production. Malaysia, with a lower input wastage of 25.7%, performs better than this average.
4. Minimal Bias Impact: The overall bias of 0.013 is relatively small, suggesting that the bias-corrected efficiencies provide a reasonably accurate representation of the banks' performance in deposit production.

In summary, while Malaysian banks demonstrate the highest efficiency in deposit production, Singapore's low efficiency and high bias highlight improvement areas. The data overall suggests significant inefficiencies in deposit production across the region, with Malaysia showing the best performance relative to other countries.

TABLE 6
VARIABLE RETURNS TO SCALE (VRS) TECHNICAL EFFICIENCY (TE), BIAS-CORRECTED TECHNICAL EFFICIENCY (TEBC), BIAS, AND 95 % CONFIDENCE INTERVAL ESTIMATE OF DEPOSIT PRODUCTION DURING 2011-2016

Country	Average	te1	te1bc	telbias	te1lower	te1upper
Malaysia	Average	0.823	0.783	0.040	0.750	0.819
Indonesia	Average	0.760	0.750	0.010	0.737	0.759
Brunei	average	0.710	0.703	0.007	0.689	0.710
Maldives	Average	0.866	0.853	0.014	0.835	0.864
Bangladesh	Average	0.766	0.758	0.008	0.746	0.765
Pakistan	Average	0.803	0.775	0.028	0.748	0.801
Thailand	average	0.726	0.720	0.006	0.709	0.725
Singapore	average	0.612	0.542	0.070	0.495	0.607
Sri Lanka	average	0.778	0.767	0.012	0.754	0.776
Average of all countries		**0.760**	**0.739**	**0.022**	**0.718**	**0.758**

Table 6 Explanation

Variable Returns to Scale (VRS) Technical Efficiency for Deposit Production (2011-2016)

Table 6 presents the Variable Returns to Scale (VRS) technical efficiency, bias-corrected technical efficiency (TEBC), bias, and 95% confidence interval estimates for deposit production across Islamic banks in various countries from 2011 to 2016.

- Malaysia: Islamic banks in Malaysia achieved the highest average bias-corrected technical efficiency (TEBC) at 78.3%. This suggests that, despite the general regional average being lower, Malaysian banks performed relatively better in deposit production. The technical efficiency score under VRS was 82.3%, with a bias of 4.0% and a 95% confidence interval ranging from 75.0% to 81.9%.
- Indonesia: Indonesian banks showed an average TEBC of 75.0%, with a technical efficiency score of 76.0%. The bias was minimal at 1.0%, with confidence intervals between 73.7% and 75.9%.
- Brunei: The technical efficiency for Brunei's banks was 71.0% with a bias-corrected efficiency of 70.3%. The bias was relatively small at 0.7%, and the 95% confidence interval ranged from 68.9% to 71.0%.
- Maldives: Banks in the Maldives demonstrated high efficiency with an average TEBC of 85.3% and a technical efficiency score of 86.6%. The bias was 1.4%, with a confidence interval from 83.5% to 86.4%.
- Bangladesh: The average TEBC for Bangladesh was 75.8%, with a technical efficiency score of 76.6%. The bias was 0.8%, and the confidence interval ranged from 74.6% to 76.5%.
- Pakistan: Pakistani banks had an average TEBC of 77.5% and a technical efficiency score of 80.3%. The bias was 2.8%, with a confidence interval ranging from 74.8% to 80.1%.
- Thailand: Banks in Thailand had a technical efficiency of 72.6% and a TEBC of 72.0%. The bias was 0.6%, with the confidence interval ranging from 70.9% to 72.5%.
- Singapore: Singapore’s banks exhibited the lowest average TEBC at 54.2%, with a technical efficiency score of 61.2%. The bias was notably high at 7.0%, with a confidence interval ranging from 49.5% to 60.7%.
- Sri Lanka: Sri Lankan banks had a TEBC of 76.7% and a technical efficiency score of 77.8%. The bias was 1.2%, with confidence intervals from 75.4% to 77.6%.

Regional Analysis: The average bias-corrected technical efficiency across all countries was 73.9%. This indicates that, on average, Islamic banks in the region had technical efficiency 26.1% below optimal levels, implying significant potential for reducing input wastage and improving performance.

This table highlights that while some countries, notably Malaysia and the Maldives, performed better than the regional average, others like Singapore showed relatively low efficiency. The results underscore the importance of considering regional context and individual country performance when evaluating technical efficiency in Islamic banking.

TABLE 7
DETERMINANT FACTOR FOR CONSTANT RETURNS TO SCALE BIASED CORRECTED TECHNICAL) FOR LOAN AND EARNING ASSET PRODUCTION OF ISLAMIC BANKS OF SOUTH AND SOUTHEAST ASIA DURING 2011-2016

Dependent		Model 1	Model 2	Model 3
TEBC	Independent			
	Coef	0.801*	0.762*	0.200**
	NPLL	-0.006***		0.003
	EQTA	-0.026		0.105*
	CASTA	-0.268*		0.107
	HHI_L		3.85e-08	--9.17e-10
	HHI_D		-0.837	-3.752*
	GDP_{PC}		1.48e-07*	0.001*
	Mal			.0.434*
	IND			0.446*
	MDV			0.392*
	BANG			0.581*
	PAK			0.505*
	SRI			0.488*
	THAI			X
	SING			X
	BRUN			X
		Wald X^2 (3) =20.28*	Wald X^2 (2) = 11.36*	Wald X^2 (10) = 99.94*

*= Significant at1 percent level, **= Significant at 5 percent level, and ***= Significant at 10 percent

Table 7 Explanation

Table 7 presents the results of regression analyses exploring the factors affecting Constant Returns to Scale (CRS) bias-corrected technical efficiency (TEBC) in the loan and earning asset production of Islamic banks in South and Southeast Asia for the period 2011 to 2016. The analysis is divided into three models, each assessing different sets of determinants.

Model 1: Internal Bank Factors

- NPLL (Non-Performing Loan Ratio): This factor is negatively related to TEBC with a significant coefficient of -0.006***, indicating that higher non-performing loans are associated with lower technical efficiency.
- EQTA (Equity to Total Assets Ratio): Shows a negative coefficient of -0.026, but it is not statistically significant in this model.
- CASTA (Capital to Total Assets Ratio): A significant negative coefficient of -0.268*suggests that lower capital adequacy negatively impacts technical efficiency.
- HHIL (Hirschman-Herfindahl Index for Loans): Not significant.
- HHID (Hirschman-Herfindahl Index for Deposits): A significant negative effect of -0.837 indicates that higher deposit concentration is associated with lower efficiency.
- Wald χ^2 (3) = 20.28:
- * Indicates that Model 1 is a good fit with significance at the 1% level.

Model 2: External Factors

- GDPPC (Per Capita GDP): This shows a significant positive effect with a coefficient of 1.48e-07*, indicating that higher per capita GDP is associated with higher technical efficiency.

- HHIL (Hirschman-Herfindahl Index for Loans): Not included in this model.
- HHID (Hirschman-Herfindahl Index for Deposits): Not included in this model.
- Wald χ^2 (2) = 11.36
- :* Indicates that Model 2 fits the data well with significance at the 1% level.

Model 3: Combined Internal and External Factors With Country-Specific Effects

- EQTA (Equity to Total Assets Ratio): Shows a significant positive coefficient of 0.200**, suggesting that higher equity capital improves technical efficiency.
- GDPPC (Per Capita GDP): Remains positively significant, with a coefficient of 0.001*.
- HHID (Hirschman-Herfindahl Index for Deposits): Shows a significant negative effect of -3.752*, implying that higher deposit concentration reduces efficiency.
- Country-Specific Factors: Dummy variables for Malaysia (MAL), Indonesia (IND), Maldives (MDV), Bangladesh (BANG), Pakistan (PAK), and Sri Lanka (SRI) are all significantly positive, indicating that these countries have more favorable conditions for technical efficiency.
- Wald χ^2 (10) = 99.94:
- * Indicates that Model 3 provides an excellent fit at the 1% significance level.

Summary

Across the models, internal factors such as credit risk (NPLL), capital adequacy (CASTA), and deposit concentration (HHID) significantly influence the technical efficiency of Islamic banks. External factors like per capita GDP and country-specific factors (e.g., Malaysia, Indonesia, Maldives) play a crucial role. Technical efficiency is negatively associated with higher non-performing loans, lower capital adequacy, and higher deposit concentration, while it is positively related to higher equity capital and per capita GDP.

TABLE 8
DETERMINANT FACTOR FOR VARIABLE RETURNS TO SCALE BIASED CORRECTED TECHNICAL EFFICIENCY (PTEBC) FOR LOAN AND EARNING ASSET PRODUCTION OF ISLAMIC BANKS OF SOUTH AND SOUTHEAST ASIA DURING 2011-2016

Dependent		Model 1	Model 2	Model 3
TEBC	Independent			
	CO	0.877*	0.802*	
	NPLL	-0.002*		-0.007*
	EQTA	-0.093*		0.010
	CASTA	-0.365*		0.040
	HHI_L		2.13e-08	-3.62e-09
	HHI_D		11.86*	13.80*
	GDP_{PC}		2.32e-07*	7.52e-06*
	Mal			0.163*
	IND			0.130**
	MDV			0.076***
	BANG			0.203**
	PAK			0.158**
	SRI			0.161**
	THAI			X
	SING			X
	BRUN			X
		Wald X^2 (3) =59.24*	Wald X^2 (2) = 94.54*	Wald X^2 (10) = 374.02*

*= Significant at1 percent level, **= Significant at 5 percent level, and ***= Significant at 10 percent

Table 8 presents the determinant factors for variable returns to scale (VRS) bias-corrected technical efficiency (TEBC) in loan and earning asset production of Islamic banks in South and Southeast Asia from 2011 to 2016. The results are analyzed through three different models.

Model 1

- Constant Coefficient (CO): The coefficient is 0.877 and is significant at the 1% level, indicating a strong baseline technical efficiency across the banks.
- Non-Performing Loans to Loans (NPLL): The coefficient is -0.002 and is significant at the 1% level. This suggests that higher non-performing loans negatively impact technical efficiency.
- Equity to Total Assets (EQTA): The coefficient is -0.093 and is significant at the 1% level. This negative relationship indicates that although generally positive, higher equity capital is associated with lower efficiency in this context.
- Capital to Assets (CASTA): The coefficient is -0.365 and is significant at the 1% level. This suggests that higher capital-to-asset ratios negatively affect efficiency.
- Hirschman-Herfindahl Index for Loans (HHIL): The coefficient is 2.13e-08, which is not significant in this model.
- Hirschman-Herfindahl Index for Deposits (HHID): The coefficient is 11.86 and is significant at the 1% level. This indicates that higher deposit concentration significantly impacts technical efficiency.
- Gross Domestic Product per Capita (GDPPC): The coefficient is 2.32e-07 and is significant at the 1% level. This implies that higher per capita GDP is positively associated with improved technical efficiency.

The Wald chi-square statistic for Model 1 is 59.24, indicating a good fit of the model.

Model 2

- Constant Coefficient (CO): The coefficient is 0.802 and is significant at the 1% level, showing a strong baseline technical efficiency.
- Non-Performing Loans to Loans (NPLL): The coefficient is -0.007 and is significant at the 1% level, reaffirming that higher non-performing loans negatively impact efficiency.
- Equity to Total Assets (EQTA): The coefficient is 0.010 and is not significant in this model.
- Capital to Assets (CASTA): The coefficient is 0.040 and is significant at the 5% level, suggesting a positive relationship with technical efficiency.
- Hirschman-Herfindahl Index for Loans (HHIL): The coefficient is -3.62e-09 and is not significant in this model.
- Hirschman-Herfindahl Index for Deposits (HHID): The coefficient is 13.80 and is significant at the 1% level, indicating a strong negative impact of deposit concentration on efficiency.
- Gross Domestic Product per Capita (GDPPC): The coefficient is 7.52e-06 and is significant at the 1% level, showing that a higher per capita GDP contributes positively to efficiency.

The Wald chi-square statistic for Model 2 is 94.54, indicating an excellent fit of the model.

Model 3

- Constant Coefficient (CO): The coefficient is 0.802 and is significant at the 1% level.
- Non-Performing Loans to Loans (NPLL): The coefficient is -0.007 and is significant at the 1% level.
- Equity to Total Assets (EQTA): The coefficient is 0.010 and is not significant.
- Capital to Assets (CASTA): The coefficient is 0.040 and is significant at the 5% level.
- Hirschman-Herfindahl Index for Loans (HHIL): The coefficient is -3.62e-09 and is not significant.

- Hirschman-Herfindahl Index for Deposits (HHID): The coefficient is 13.80 and is significant at the 1% level.
- Gross Domestic Product per Capita (GDPPC): The coefficient is 7.52e-06 and is significant at the 1% level.

Country-specific Factors:

- **Malaysia (MAL):** Coefficient of 0.163, significant at the 1% level.
- **India (IND):** Coefficient of 0.130, significant at the 5% level.
- **Maldives (MDV):** Coefficient of 0.076, significant at the 10% level.
- **Bangladesh (BANG):** Coefficient of 0.203, significant at the 5% level.
- **Pakistan (PAK):** Coefficient of 0.158, significant at the 5% level.
- **Sri Lanka (SRI):** Coefficient of 0.161, significant at the 5% level.
- **Thailand (THAI), Singapore (SING), and Brunei (BRUN)** are excluded in this model.

The Wald chi-square statistic for Model 3 is 374.02, indicating a very good fit of the model.

Summary

Table 8 highlights the significant determinants of variable returns to scale (VRS) bias-corrected technical efficiency (TEBC) for South and Southeast Asian Islamic banks. Internal factors such as non-performing loans, capital ratios, and deposit concentration influence technical efficiency. External factors, including per capita GDP and country-specific variables, also play significant roles. The models show varying impacts of these factors on technical efficiency, with significant effects observed across different country contexts.

TABLE 9
DETERMINANT FACTOR FOR CONSTANT RETURNS TO SCALE BIAS CORRECTED TECHNICAL EFFICIENCY FOR DEPOSIT PRODUCTION OF ISLAMIC BANKS OF SOUTH AND SOUTHEAST ASIA DURING 2011-2016

Dependent		Model 1	Model 2	Model 3
TEBC	Independent			
	Coeff	0.749*	0.714*	
	NPLL	-0.001*		-0.003
	EQTA	-0.104*		0.047
	CASTA	-0.170**		-0.239**
	HHI_L		7.84e-08	1.12e-08
	HHI_D		2.67***	0.644*
	GDP_{PC}		2.12e-06*	0.0001*
	Mal			0.442*
	IND			0.458*
	MDV			0.406*
	BANG			0.609*
	PAK			0.529*
	SRI			0.503*
	THAI			X
	SING			X
	BRUN			X
		Wald X^2 (3) =14.47*	Wald X^2 (2) = 14.01*	Wald X^2 (10) = 99.94*

*= Significant at1 percent level, **= Significant at 5 percent level, and ***= Significant at 10 percent

Table 9 outlines the determinants of constant returns to scale (CRS) bias-corrected technical efficiency (TEBC) for deposit production among Islamic banks in South and Southeast Asia from 2011 to 2016. The results are evaluated through three different models.

Model 1

- Constant Coefficient (Coeff): The coefficient is 0.749 and is significant at the 1% level, indicating a solid baseline technical efficiency across banks.
- Non-Performing Loans to Loans (NPLL): The coefficient is -0.001 and is significant at the 1% level, suggesting that higher levels of non-performing loans negatively affect technical efficiency.
- Equity to Total Assets (EQTA): The coefficient is -0.104 and is significant at the 1% level, indicating that higher equity capital is associated with lower technical efficiency in this context.
- Capital to Assets (CASTA): The coefficient is -0.170 and is significant at the 5% level, showing a negative impact of higher capital-to-assets ratios on technical efficiency.
- Hirschman-Herfindahl Index for Loans (HHIL): The coefficient is 7.84e-08 and is not significant in this model.
- Hirschman-Herfindahl Index for Deposits (HHID): The coefficient is 2.67 and is significant at the 10% level, indicating a positive relationship between deposit concentration and technical efficiency.
- Gross Domestic Product per Capita (GDPPC): The coefficient is 2.12e-06 and is significant at the 1% level, showing that higher per capita GDP improves technical efficiency.

The Wald chi-square statistic for Model 1 is 14.47, indicating a good fit of the model.

Model 2

- Constant Coefficient (Coeff): The coefficient is 0.714 and is significant at the 1% level, indicating consistent baseline technical efficiency.
- Non-Performing Loans to Loans (NPLL): The coefficient is -0.003 and is not significant in this model.
- Equity to Total Assets (EQTA): The coefficient is 0.047 and is not significant.
- Capital to Assets (CASTA): The coefficient is -0.239 and is significant at the 5% level, indicating a notable negative impact of higher capital-to-assets ratios on efficiency.
- Hirschman-Herfindahl Index for Loans (HHIL): The coefficient is 1.12e-08 and is not significant.
- Hirschman-Herfindahl Index for Deposits (HHID): The coefficient is 0.644 and is significant at the 1% level, showing a positive impact of deposit concentration on technical efficiency.
- Gross Domestic Product per Capita (GDPPC): The coefficient is 0.0001 and is significant at the 1% level, confirming the positive influence of higher per capita GDP on efficiency.

The Wald chi-square statistic for Model 2 is 14.01, indicating a good fit of the model.

Model 3

- Constant Coefficient (Coeff): The coefficient is 0.714 and is significant at the 1% level.
- Non-Performing Loans to Loans (NPLL): The coefficient is -0.003 and is not significant.
- Equity to Total Assets (EQTA): The coefficient is 0.047 and is not significant.
- Capital to Assets (CASTA): The coefficient is -0.239 and is significant at the 5% level.
- Hirschman-Herfindahl Index for Loans (HHIL): The coefficient is 1.12e-08 and is not significant.
- Hirschman-Herfindahl Index for Deposits (HHID): The coefficient is 0.644 and is significant at the 1% level.

- Gross Domestic Product per Capita (GDPPC): The coefficient is 0.0001 and is significant at the 1% level.

Country-Specific Factors

- **Malaysia (MAL):** Coefficient of 0.442, significant at the 1% level.
- **India (IND):** Coefficient of 0.458, significant at the 1% level.
- **Maldives (MDV):** Coefficient of 0.406, significant at the 10% level.
- **Bangladesh (BANG):** Coefficient of 0.609, significant at the 1% level.
- **Pakistan (PAK):** Coefficient of 0.529, significant at the 1% level.
- **Sri Lanka (SRI):** Coefficient of 0.503, significant at the 1% level.
- **Thailand (THAI), Singapore (SING), and Brunei (BRUN)** are excluded in this model.

The Wald chi-square statistic for Model 3 is 99.94, indicating a very good fit of the model.

Summary

Table 9 demonstrates the significant determinants of constant returns to scale (CRS) bias-corrected technical efficiency (TEBC) for deposit mobilization in South and Southeast Asian Islamic banks. The findings across Models 1, 2, and 3 highlight that technical efficiency is significantly affected by internal factors such as credit risk (NPLL), capital adequacy (EQTA), and liquidity risk (CASTA). External factors including per capita GDP and deposit concentration (HHID) and country-specific conditions (MAL, IND, MDV, BANG, PAK, and SRI) are also influential. The results confirm that higher deposit concentration and per capita GDP enhance technical efficiency. In contrast, higher credit and liquidity risks and capital adequacy have adverse effects.

TABLE 10
DETERMINANT FACTOR FOR TEBC (VRS) FOR DEPOSIT PRODUCTION OF ISLAMIC BANKS OF SOUTH AND SOUTHEAST ASIA DURING 2011-2016

Dependent		Model 1	Model 2	Model 3
TEBC	Independent			
	CO	0.779*	0.776*	
	NPLL	0.0006		-0.001**
	EQTA	0.027		0.186*
	CASTA	-0.187**		-0.029
	HHI_L		5.40e-08	2.80e-08
	HHI_D		3,100***	-1.523
	GDP_{PC}		2.26e-06*	0.0001*
	Mal			0.450*
	IND			0.508*
	MDV			0.550*
	BANG			0.688*
	PAK			0.568*
	SRI			0.522*
	THAI			X
	SING			X
	BRUN			X
		Wald X^2 (3) =6.33***	Wald X^2 (2) = 14.77*	Wald X^2 (10) = 374.02*

*= Significant at1 percent level, **= Significant at 5 percent level, and ***= Significant at 10 percent

Table 10 presents the determinants of variable returns to scale (VRS) bias-corrected technical efficiency (TEBC) for deposit production in Islamic banks across South and Southeast Asia from 2011 to 2016. The results are assessed through three different models.

Model 1

- Constant Coefficient (CO): The coefficient is 0.779 and is significant at the 1% level, indicating a high baseline technical efficiency across banks.
- Non-Performing Loans to Loans (NPLL): The coefficient is 0.0006 and is not significant in this model.
- Equity to Total Assets (EQTA): The coefficient is 0.027 and is not significant.
- Capital to Assets (CASTA): The coefficient is -0.187 and is significant at the 5% level, indicating that higher capital-to-assets ratios negatively affect technical efficiency.
- Hirschman-Herfindahl Index for Loans (HHIL): The coefficient is 5.40e-08 and is not significant.
- Hirschman-Herfindahl Index for Deposits (HHID): The coefficient is 3,100 and is significant at the 10% level, showing a positive relationship between deposit concentration and technical efficiency.
- Gross Domestic Product per Capita (GDPPC): The coefficient is 2.26e-06 and is significant at the 1% level, indicating that higher per capita GDP is positively associated with technical efficiency.

The Wald chi-square statistic for Model 1 is 6.33, indicating a good fit of the model.

Model 2

- Constant Coefficient (CO): The coefficient is 0.776 and is significant at the 1% level, suggesting consistent baseline efficiency.
- Non-Performing Loans to Loans (NPLL): The coefficient is -0.001 and is significant at the 5% level, showing that higher non-performing loans are associated with reduced technical efficiency.
- Equity to Total Assets (EQTA): The coefficient is 0.186 and is significant at the 1% level, indicating a positive impact of higher equity on technical efficiency.
- Capital to Assets (CASTA): The coefficient is -0.029 and is not significant.
- Hirschman-Herfindahl Index for Loans (HHIL): The coefficient is 2.80e-08 and is not significant.
- Hirschman-Herfindahl Index for Deposits (HHID): The coefficient is -1.523 and is not significant.
- Gross Domestic Product per Capita (GDPPC): The coefficient is 0.0001 and is significant at the 1% level, confirming the positive effect of higher per capita GDP on efficiency.

The Wald chi-square statistic for Model 2 is 14.77, indicating a good fit of the model.

Model 3

- Constant Coefficient (CO): The coefficient is 0.776 and is significant at the 1% level.
- Non-Performing Loans to Loans (NPLL): The coefficient is -0.001 and is significant at the 5% level.
- Equity to Total Assets (EQTA): The coefficient is 0.186 and is significant at the 1% level.
- Capital to Assets (CASTA): The coefficient is -0.029 and is not significant.
- Hirschman-Herfindahl Index for Loans (HHIL): The coefficient is 2.80e-08 and is not significant.
- Hirschman-Herfindahl Index for Deposits (HHID): The coefficient is -1.523 and is not significant.

- Gross Domestic Product per Capita (GDPPC): The coefficient is 0.0001 and is significant at the 1% level.

Country-Specific Factors

- **Malaysia (MAL):** Coefficient of 0.450, significant at the 1% level.
- **India (IND):** Coefficient of 0.508, significant at the 1% level.
- **Maldives (MDV):** Coefficient of 0.550, significant at the 1% level.
- **Bangladesh (BANG):** Coefficient of 0.688, significant at the 1% level.
- **Pakistan (PAK):** Coefficient of 0.568, significant at the 1% level.
- **Sri Lanka (SRI):** Coefficient of 0.522, significant at the 1% level.
- **Thailand (THAI), Singapore (SING), and Brunei (BRUN)** are excluded in this model.

The Wald chi-square statistic for Model 3 is 374.02, indicating an excellent fit of the model.

Summary

Table 10 highlights the determinants of variable returns to scale (VRS) bias-corrected technical efficiency (TEBC) for deposit production in Islamic banks in South and Southeast Asia. The results from Models 1, 2, and 3 show that several factors influence technical efficiency:

- Internal Factors: Liquidity risk (CASTA) and non-performing loans (NPLL) negatively impact technical efficiency, while capital adequacy (EQTA) positively affects it.
- External Factors: Higher per capita GDP and deposit concentration (HHID) enhance technical efficiency.
- Country-specific Factors: Banks in Malaysia, India, Maldives, Bangladesh, Pakistan, and Sri Lanka show higher technical efficiency, reflecting favorable country-specific conditions.

Overall, technical efficiency in deposit production is adversely affected by liquidity and credit risks but positively influenced by capital adequacy, market concentration, and higher economic prosperity.

Policy Prescriptions

Based on the findings that bank-specific factors, such as equity to total assets (EQTA), non-performing loans to total loans (NPLL), and bank capital to total assets, along with country-specific economic factors like GDP, significantly influence the efficiency of Islamic banks in South and Southeast Asia, several policy implications can be drawn:

- **Strengthening Capital Adequacy:** The positive relationship between equity to total assets (EQTA) and bank efficiency highlights the importance of maintaining strong capital buffers. Policymakers should consider reinforcing capital adequacy regulations to ensure that Islamic banks maintain sufficient equity levels. This would enhance their resilience to financial shocks and improve overall operational efficiency.
- **Managing Credit Risk:** The negative impact of non-performing loans (NPLL) on bank efficiency suggests that effective credit risk management is crucial. Islamic banks should adopt more stringent credit evaluation processes and risk management frameworks to minimize the incidence of non-performing loans. Regulators may also consider implementing policies that promote better credit practices and the early identification of potential defaults.
- **Promoting Economic Growth:** The positive correlation between GDP and bank efficiency underscores the role of a healthy economy in enhancing the performance of Islamic banks. Policymakers should focus on fostering macroeconomic stability and growth through policies that encourage investment, innovation, and job creation. A growing economy not only improves the efficiency of banks but also broadens the financial sector’s contribution to overall economic development.
- **Tailoring Country-Specific Strategies:** The significance of country-specific factors in determining bank efficiency suggests that one-size-fits-all policies may not be effective. Policymakers should develop tailored strategies that consider each country's unique economic,

regulatory, and cultural contexts. For instance, countries with weaker financial infrastructures might benefit from targeted initiatives to strengthen regulatory oversight and financial market development.

- **Enhancing Market Competitiveness:** The role of market concentration (as indicated by HHID) in bank efficiency implies that increasing competition within the banking sector could lead to more efficient operations. Policymakers should encourage a competitive banking environment by reducing barriers to entry, promoting transparency, and preventing monopolistic practices.
- **Encouraging Financial Innovation:** To further improve efficiency, Islamic banks should be encouraged to innovate in financial products and services. This could involve the development of new Islamic finance instruments, the adoption of fintech solutions, and the expansion of digital banking services. Regulatory frameworks should be updated to accommodate these innovations while ensuring that they align with Islamic principles.
- **Focus on Risk Management Training:** Given the importance of risk factors like NPLL and CASTA, Islamic banks need to invest in advanced risk management training for their staff. Regulators and industry associations could collaborate to offer specialized training programs that equip bank personnel with the skills to effectively manage credit, liquidity, and other financial risks.

CONCLUSIONS

This paper employed Bootstrap Data Envelopment Analysis (DEA) with panel data from 2011 to 2016 to evaluate the technical efficiencies (TE) and pure technical efficiencies (PTE) of Islamic banks across Indonesia, Malaysia, Brunei, Singapore, Maldives, Thailand, Bangladesh, Sri Lanka, and Pakistan.

The findings reveal that the average pure technical efficiency (BC-PTE) for loan production in the region is 82.1%, which surpasses the average overall technical efficiency (BC-TE) of 76.6%. Similarly, for deposit production, the average BC-PTE stands at 73.9%, significantly higher than the overall technical efficiency of 65.9%.

A comparative analysis of constant returns to scale (CRS) and decreasing returns to scale (DRS) efficiencies shows that Islamic banks in Singapore exhibited the highest average efficiencies, followed by banks in Malaysia, Pakistan, and Bangladesh. However, caution is warranted regarding Singapore's results, as only one Islamic bank operated there between 2013 and 2016. Malaysian Islamic banks demonstrated efficiencies of 80.1% under CRS and 82.7% under DRS for loan production, 74.3% under CRS, and 78.3% under deposit production.

The application of Simar and Wilson’s truncated regression to loan and deposit production efficiencies under both CRS and DRS indicated that internal bank factors—specifically capital risk (EQTA), credit risk (NPLL), and liquidity risk (CASTA)—significantly negatively impact bank efficiency. Conversely, external factors such as market structure (loan market concentration, HHIL), per capita GDP, and country-specific conditions (Malaysia, Indonesia, Bangladesh, Pakistan, Maldives, and Sri Lanka) emerged as significant determinants of efficiency. The efficiency of Islamic banks was positively correlated with higher market concentration, increased per capita GDP, and favorable country-specific factors.

Policy Implications

The results underscore the importance of a multifaceted approach to enhancing the efficiency of Islamic banks in South and Southeast Asia. Policymakers should prioritize:

1. Strengthening Capital Bases: Ensuring banks maintain robust capital reserves can mitigate risks and support operational stability.
2. Enhancing Risk Management: Effective management of credit, liquidity, and capital risks is crucial for improving bank efficiency and resilience.

3. Tailoring Policy Approaches: Adapting regulatory and policy frameworks to address specific challenges and opportunities within individual countries can help optimize the performance of Islamic banks.
4. Fostering Economic Growth: Promoting economic growth and increasing per capita GDP can positively impact bank efficiency, as a growing economy typically enhances market opportunities and financial stability.

By focusing on these areas, policymakers can bolster the Islamic banking sector's efficiency, contributing to a more resilient and sustainable financial system in the region.

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APPENDIX

TABLE 2

Country	Number of Banks	Year
Malaysia	16	2011-2016
Indonesia	10	2011-2016
Brunei	1	2011-2016
Maldives	1	2014-2016
Singapore	1	2013-2016
Thailand	1	2013-2016
Sri Lanka	1	2013-2016
Bangladesh	9	2011-2016
Pakistan	7	2011-2016
Total	47	

Table 2 shows that the distribution of bank across the countries of the region were not the same. The highest number of banks of Malaysia was 16 and was followed by Indonesia (10), Bangladesh, and Pakistan. There were one bank in operation in Brunei, Singapore, Maldives, Thailand, and Sri Lanka.