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IMPACT OF BANKING SUPERVISION ON THE COST-EFFICIENCY OF BANKS: A STUDY OF FIVE DEVELOPING ASIAN COUNTRIES

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🆔 Liang, Lien-Wen[1+]
Dash Altankhuyag[2]

[1]Associate Professor, Department of Banking & Finance, Chinese Culture University, Taiwan
Email: liang.lienwen@gmail.com Tel: +886-228610511

[2]General Manager, Luxury Stone Craft Granite and Marble LLC, USA
Email: Globus04@gmail.com Tel: + 001-7038621999

(+ Corresponding author)

ABSTRACT

The main purpose of banking supervision is to ensure stable banking operations, minimize the risk to the stability of financial systems, increase banking efficiency, and promote competitiveness. However, the question is whether, and how, banking supervision benefits or damages banking efficiency. The purpose of this study is to investigate the different effects of financial regulations on the cost-efficiency of the banking industries in India, Thailand, Bangladesh, Malaysia, and Mongolia, by employing the stochastic frontier approach (SFA) and stochastic metafrontier function (SMF) for a sample of 141 commercial banks between 2000 and 2010. The findings show that bank efficiency is not significantly influenced by the minimum capital requirements; however, higher capitalization helps to alleviate agency problems between managers and shareholders, and gives shareholders greater incentives to monitor management's performance and ensure that their banks operate efficiently. Finally, for banking supervision in the five countries, SMF is estimated under the metafrontier cost function, whether a technology gap ratio (TGR) or meta-cost efficiency (MCE). It is revealed that Indian banks have the best results with TGR and MCE at 0.7527 and 0.6715, respectively, while Thailand has the lowest TRG value at 0.4608 and Malaysia the lowest MCE value at 0.3531.

Contribution/Originality: This study is one of very few that has investigated how banking supervision benefits or damages banking efficiency in developing Asian countries. Instead of programming techniques, we applied SMF proposed by Huang *et al.* (2014) to obtain the estimates of the metafrontier. We found that banking efficiency is not significantly influenced by capital regulations, but that higher capital ratios are related to greater efficiency.

1. INTRODUCTION

Banking is one of the most regulated industries in the world (Santos, 2001; Chortareas *et al.*, 2012; Fernando and Nimal, 2014; Syadullah, 2018) the purpose of financial supervision being to restrict high-risk business practices and protect depositors. Tightening up regulations may reduce the probability of bank crises, but too many restrictions on banks' activities harm profitability and efficiency. In his autobiography, the former Federal Reserve Chair (Greenspan, 2007) praises financial markets as the most effective, commenting that only the foolish would require more financial regulation.

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Since the 1970s, most of the world's major economies have adopted deregulation policies to promote financial liberalization and internationalization, thereby accelerating economic growth and development. Since the 1980s, many new emerging economies have started to follow their example and also promote financial deregulation. However, the US subprime crisis alerted governments worldwide to the necessity for reinstating control over the banking sector; the reversion to narrow banking from universal banking has thus been discussed (De Grauwe, 2008).

The trend in financial liberalization, initially led by the United States, has also contributed to gradual financial reform across the world. Since the 1990s, the European Union and developed Asian countries, such as Japan, South Korea, Singapore, and Taiwan, have gradually implemented regulations to relax banking restrictions and permit financial liberalization. This has resulted in the financial systems of many countries starting to encourage competition, allowing more flexible and diverse financial operations and significantly enhancing banking efficiency and competiveness. Consequently, no conflict exists between financial liberalization and stability.

However, the illusion of harmony between financial liberalization and stability collapsed during the 2007 subprime mortgage crisis, which reflects the correlation between financial liberalization and fragility explained by Hellmann *et al.* (1994) and Demirgüç-Kunt and Detragiache (1998). In addition, the reduced entry barriers consequent to financial liberalization could reduce the franchise values of banks: banks must take greater risks to offset their loss of monopoly profits, which reduces internal risk management and increases financial instability. To some extent, this explains the 2008 financial crisis.

Minsky (1982) developed the financial instability hypothesis in the 1980s, arguing that instability is not endogenous to a capitalist economy but a normal phenomenon; economic stability is maintained by changes in institutional structures, policies, and exogenous reactions of economic units. Therefore, Minsky believed governments must intervene on occasion to control financial instability and offered useful analysis and advice to financial regulatory authorities. Barth *et al.* (2004; 2006; 2008) used economic theories to provide conflict predictions and discussed the effects of laws, regulations, and supervisory policies on the performance of banks.

Following the 2008 financial crisis, many studies focused on the importance of strengthening banking capital requirements to reduce the risk and prevent the failure of banks (Gorton and Winton, 1995; Hovakimian and Kane, 2000; Barth *et al.*, 2013). In contrast, some studies found that excessive regulation could interfere with banking performance: insufficient capital could increase the risk of bank bankruptcies, while excessive capital could increase bank costs unnecessarily, thereby leading to adverse effects on customers and the efficiency of the banking system (Chortareas *et al.*, 2012; Chidoko and Mashavira, 2014; Yuliansyah, 2015; Yamaguchi, 2018). The effect of financial supervision on banking performance has always been debatable, but DeYoung (1998) found that there were very few studies investigating the issue. In fact, Berger and Humphrey (1997) summarized 122 studies focusing on the efficiency of financial institutions but only 28 studies on government policies. Specifically, little empirical evidence exists on the relationship between regulatory and supervisory policies and various aspects of banking performance and efficiency (Chortareas *et al.*, 2012).

We employ Battese and Coelli (1995) stochastic frontier approach (SFA) to implement the maximum likelihood estimation method for determining the stochastic cost function and inefficient model simultaneously. By estimating the effect of the extent of banking supervision, we then determine the critical factors affecting the cost inefficiency of banks in India, Thailand, Bangladesh, Malaysia, and Mongolia. Finally, using Huang *et al.* (2014) metafrontier approach, we calculate the technology gap ratios (TGR) and meta-cost efficiencies (MCE) of these banks to compare their efficiency.

This paper is structured as follows: Section 2 presents the literature review, Section 3 explains the methodology and a data source, Section 4 discusses the empirical results, and Section 5 provides our conclusions.

2. LITERATURE REVIEW

2.1. Effect of Financial Supervision on Banking Efficiency

The few studies on the impact of financial liberalization, regulation, and supervision on banking efficiency are inconclusive (Mester, 1996; Berger and Humphrey, 1997; Barth *et al.*, 2001; Claessens and Laeven, 2004; Orji *et al.*, 2018). Fernández and Gonzalez (2005) examined a sample of listed banks over the same period and found evidence that in those countries with low accounting and auditing requirements and more powerful supervisory authorities, the risk-taking behavior of managers may be reduced. Moreover, they indicated that the higher the restrictions on banking activities, the lower the probability of a banking crisis.

In fact, several researchers have shown that financial regulation and supervision have a positive impact on banking efficiency. Demirgüç-Kunt *et al.* (2006) believed that effective banking supervision could improve banking operations; however, if banking supervision is the core issue, then banks must comply with information disclosure policies. Beck *et al.* (2006) also believed that financial supervisory measures promoted by the government reduced market failures and corruption in banks and improved banking intermediary functions.

Other researchers have stated that financial regulation and supervision exert negative effects, though. Becker (1983) and Shleifer and Vishny (1989) argued that strong financial supervisory measures were unfavorable to banking performance, especially when banks might put their own interests above the benefit to society. Barth *et al.* (2001) highlighted that the more banking activities were restricted, the more likely banking efficiency would be reduced. Levine (2004) noted that government regulations might negatively affect commercial banks as well. Barth *et al.* (2004) went further and examined the effects of regulation and supervision on the stability, development, and performance of banks: when the empirical results revealed a negative correlation between banking regulations and banking stability and development, they argued that successful government supervision should authorize the private sector but not restrict banking activities. Demirguc–Kunt *et al.* (2004) used financial ratios to investigate the effect of banking regulations, market structure, and state institutions on financial intermediation costs: the empirical results also showed how more stringent restrictions on banking services and activities increased financial intermediation costs. Furthermore, Hermes and Nhung (2010) found a positive correlation between financial liberalization and banking efficiency, indicating again that increasing restrictions increased the possibility that efficiency would decline. Barth *et al.* (2013) and Haque and Brown (2017) similarly demonstrated that tighter restrictions on banking activities negatively affected banking efficiency.

Another issue of concern regarding financial supervision is capital adequacy. When the *International Convergence of Capital Measurement and Capital Standards (Basel I)* was implemented in early 1992, along with Basel II in 2007 and Basel III in 2013, capital adequacy became an important measure. Banking regulations requiring higher capital adequacy could positively affect the banking sector (Mester, 1996; Laeven and Levine, 2009). However, some studies reached different conclusions: some found adequate capital increased risk-taking behavior (Besanko and Kanatas, 1996; Blum, 1999).

Laeven and Levine (2009) specifically found that the highest minimum capital requirement enhanced bank stability while the lowest could reduce operational risks. As well as showing a positive correlation between more stringent regulations and banking efficiency, Barth *et al.* (2013) found that a strengthening of official supervisory powers was only positively associated with banking efficiency in countries with independent regulatory authorities. Behr *et al.* (2010) previously found that stronger market competition reduced the franchise values of banks, indicating a negative correlation between adequate capital and risk. Cheng *et al.* (2010) explored the different effects supervision policies exerted on the cost-efficiency of Taiwanese and Japanese banks: the empirical results revealed that after the implementation of a differentiated supervision policy, increasing capital adequacy requirements or decreasing non-performing loan ratios reduced cost-efficiency.

In addition, Barth *et al.* (2004) believed that although stringent requirements reduced overdue bank loans, this was not necessarily related to stability, development, and performance in the banking sector. Pasiouras *et al.* (2009)

subsequently divided financial supervisory measures into capital adequacy requirements, restrictions on banking activities, market discipline, official supervisory powers, and deposit insurance, among others, to determine the effects of each on banking performance. Their empirical results revealed that more positive official supervision and enhanced market discipline were positively correlated to efficiency, while regulation of banking activities could lead to negative effects on cost-efficiency and positive effects on profit efficiency. Finally, Georgios *et al.* (2012) showed how capital adequacy requirements and official supervisory powers could positively affect banking performance, which could be significantly increased by further enhancing those requirements or powers. In contrast, restrictions on banking activities and domestic supervision could adversely affect banking performance.

2.2. Investigation into the Banking Efficiency of Five East Asian Countries

With regard to such issues as banking efficiency in Asian countries, most developed countries place great importance on the share structures (Fukuyama *et al.*, 1999; Morck *et al.*, 2000), mergers and acquisitions (Lee *et al.*, 2013) and size of McKillop *et al.* (1996); Drake *et al.* (2006) and impact of financial crisis on Huang *et al.* (2014) public and private institutions.

In developing countries, studies presenting literature reviews of banking and efficiency have attracted much attention. Bhattacharyya *et al.* (1997) conducted a study on the efficiency of commercial banks in India to investigate the effects on banking performance of reforms in the financial sectors: the results revealed that both banking performance and efficiency in India improved from a more liberalized environment. Using data envelopment analysis (DEA), Sathye (2003) also measured the efficiency of commercial banks in India, discovering that the average efficiency was lower than the global standard and improvements were still required. Thus, compared with domestic public and private banks, foreign ones are more efficient. Das and Ghosh (2009) used DEA as well, to investigate both the cost- and profit efficiencies of Indian commercial banks in terms of financial liberalization and the significance of income and non-efficient activities in banks that exhibit high cost- and low profit efficiency.

For Thailand, Chantapong (2005) investigated the effect of foreign investments on the efficiency of commercial banks. The empirical results showed how the business structure, management, and key clients of foreign banks differed from domestic ones, and they appeared more efficient in capital adequacy and overdue loans. This study further assumed that the entry of foreign banks and competition generated from mergers and acquisitions had improved the cost-efficiency of domestic banks. Okuda and Rungsomboon (2006) revealed a difference in cost-efficiency skills between foreign and domestic banks, based on empirical results of the reduction in operational costs of domestic banks after changes to Thailand's monetary policies. Finally, Chansarn (2008) conducted an empirical analysis of different-sized banks in Thailand, and the results showed that size did not affect banking performance, particularly in cost and income management; in other words, there were no differences found between banks of different sizes.

Yasmeen (2011) investigated the technical efficiency and productivity growth of commercial banks in Bangladesh and found that enhancements in technical efficiency not only increased the number of efficient banks but also improved their efficiency. Uddin and Suzuki (2011) meanwhile, investigated the performance of commercial banks following financial reform in Bangladesh and discovered that whereas the income and cost-efficiency of a sample of banks had increased by 15.28 percent in 2001, the increase was 37.84 percent in 2008. Similarly, non-performing loans (NPL) and return on assets (ROA) also revealed an improvement in banking performance, indicating the statistically significant positive impact of foreign ownership; on the other hand, although private ownership positively affects income efficiency, ROA, and NPL, cost-efficiency is negatively affected.

In Malaysia, Omar *et al.* (2006) used the Malmquist Index and DEA to investigate productivity in the banking sector, the empirical results of which revealed significant potential for progress, suggesting that banks—particularly the small Islamic banks—should expand and enhance their technical efficiency through mergers and acquisitions. Tahir and Bakar (2009) also used DEA to investigate pure technical and size efficiencies of commercial

banks in Malaysia. Their results showed the pure technical efficiency of domestic banks was below their size efficiency, indicating they lacked efficiency in cost control in comparison to their size. In contrast, the pure technical efficiency is greater than size efficiency in foreign banks. Tahir *et al.* (2010) employed the stochastic frontier approach (SFA), though, to investigate cost- and profit efficiencies between domestic and foreign banks in Malaysia. Their results showed that while cost-efficiency was higher in domestic than foreign banks, their profit efficiency was lower. In fact, during the study period, one-third of domestic banks experienced low profitability.

Finally, for Mongolia, Gan–Ochir (2008) demonstrated that strengthening financial supervision and regulation is most effective in dealing with the risks associated with capital inflows. Thus, the authorities should continue to upgrade their supervisory framework by improving prudent regulation and supervision of the liquidity and operational risks of banks. In Mongolia, the banking industry is significantly more competitive than previously, and likely to become more so as new competitive pressures from overseas emerge as a result of new banking technologies. Therefore, Tegshee (2009) examined the major factors behind the banking sector's competitiveness and profitability and discovered that the profitability and scale efficiency of commercial banks were positively and significantly related to competitiveness. Finally, Tsolmon (2010) noted that the efforts to restructure the Mongolian banking sector during the 1990s had limited success: the banking crises resulted in bank closures and significant injections of public funds. However, financial reform has progressed since 2000, particularly in bank restructures and privatization: the findings suggested efficient banking distribution channels could be developed to enhance the ability of banks to collect and mobilize financial resources, while adopting the Basel Accord would encourage better risk management and provide financial stability.

To conclude, most studies on banking efficiency in various developed countries in Asia focused on public and private institutions and their share structures. However, as financial regulatory and supervisory measures vary significantly across developed and developing countries and the stringency of those measures could greatly affect banking performance, this study further analyzes this issue.

3. MODEL SPECIFICATION AND VARIABLE SELECTION

Based on Battese and Coelli (1995) this study defines the following stochastic translog cost function with three inputs and three outputs.

3.1. Stochastic Cost Frontier Function

$$\ln\left(\frac{TC_{it}}{P_{2it}}\right) = \alpha_0 + \alpha_1 \ln Y_{1it} + \alpha_2 \ln Y_{2it} + \alpha_3 \ln Y_{3it} + \beta_1 \ln\left(\frac{P_{1it}}{P_{2it}}\right) + \beta_3 \ln\left(\frac{P_{3it}}{P_{2it}}\right) + \frac{1}{2}\alpha_{11}(\ln Y_{1it})^2$$

$$+ \frac{1}{2}\alpha_{22}(\ln Y_{2it})^2 + \frac{1}{2}\alpha_{33}(\ln Y_{3it})^2 + \alpha_{12}\ln Y_{1it}\ln Y_{2it} + \alpha_{13}\ln Y_{1it}\ln Y_{3it} + \alpha_{23}\ln Y_{2it}\ln Y_{3it}$$

$$+ \frac{1}{2}\rho_{11}\left(\ln\frac{P_{1it}}{P_{2it}}\right)^2 + \frac{1}{2}\rho_{33}\left(\ln\frac{P_{3it}}{P_{2it}}\right)^2 + \rho_{13}\ln\left(\frac{P_{1it}}{P_{2it}}\right)\ln\left(\frac{P_{3it}}{P_{2it}}\right) + \gamma_{11}\ln Y_{1it}\ln\left(\frac{P_{1it}}{P_{2it}}\right)$$

$$+ \gamma_{13}\ln Y_{1it}\ln\left(\frac{P_{3it}}{P_{2it}}\right) + \gamma_{21}\ln Y_{2it}\ln\left(\frac{P_{1it}}{P_{2it}}\right) + \gamma_{23}\ln Y_{2it}\ln\left(\frac{P_{3it}}{P_{2it}}\right) + \gamma_{31}\ln Y_{3it}\ln\left(\frac{P_{1it}}{P_{2it}}\right)$$

$$+ \gamma_{33}\ln Y_{3it}\ln\left(\frac{P_{3it}}{P_{2it}}\right) + v_{it} + u_{it} , \tag{1}$$

where TC_{it} represents the decision-making unit's (DMU) total cost, Y_n represents the nth output (loans, investment, and non-interest income, respectively), P_m represents the mth input price (price of funding, labor, and capital, respectively), i represents the banking firm, $\alpha, \beta, \delta, \gamma, \text{and } \rho$ represent the parameters to be estimated, v_{it} and u_{it} represent random error terms that are assumed individually and mutually independent, and u_{it} represents a function of firm-specific factors that affect cost inefficiency. Specifically, u_{it} belongs to a truncated normal distribution given by $u_{it} \sim N^+\left(m_{it}, \sigma_u^2\right)$.

We also identify the following regression model for capturing the main determinants of X-inefficiency:

$$m_{i,t} = \delta_0 + \delta_1 B_{1,it} + \delta_2 B_{2,it} + \delta_3 B_{3,it} + \delta_4 B_{4,it}, \tag{2}$$

where $B_{1,it}$ is a dummy variable that provides for the minimum capital requirement: it is set to 1 if the capital adequacy ratio complies with the minimum requirement and 0 otherwise, at time t. In addition, $B_{2,it}$ represents the equity to total assets ratio at time t, $B_{3,it}$ represents the net interest margin (NIM) at time t, $B_{4,it}$ represents the Herfindahl–Hirschman Index (HHI) at time t, and δ is a vector of parameters to be estimated.

3.2. Stochastic Metafrontier Approach

Huang $et\ al.$ (2014) model is used to estimate the cost function. Suppose that for the jth cost group, such as a country, the stochastic frontier of the ith DMU, or a bank, in the tth period is modeled as:

$$C_{jit} = f_t^j(X_{jit})e^{V_{jit}+U_{jit}}, \text{j} = 1, 2, \ldots, \text{J}; \text{i} = 1, 2, \ldots, N_j; \text{t} = 1, 2, \ldots, \text{T}, \tag{3}$$

where C_{jit} and X_{jit} denote the cost and input vectors, respectively, of the ith bank from the jth group in the tth period. We note that the function $f_t^j(\ )$ of the cost frontier has both a subscripted t and superscripted j, meaning the individual group-specific cost technology may vary across groups and time. For example, in $f_t^j(X_{jit}) = e^{X_{jit}\beta_t^j}$, β_t^j denotes the parameters associated with the jth group's frontier in the tth period. Following standard stochastic frontier modeling, the random errors V_{jit} represent statistical noise and the non-negative random errors U_{jit} cost inefficiency. Here, we assume V_{jit} is distributed independently and identically as $N(0, \sigma_{V(j)}^2)$ and independent of U_{jit}, which follows the truncated normal distribution as $N^+[\mu^j(Z_{jit}), \sigma_{v(j)}^2(Z_{jit})]$, where Z_{jit} are exogenous variables.

A DMU_i's cost-efficiency (CE) is defined as:

$$CE_{it}^j = \frac{C_{jit}}{f_t^j(X_{jit})e^{V_{jit}}} = e^{-U_{jit}} \qquad (4)$$

Cost-efficiency is accounted for by the group-specific exogenous variables Z_{jit}. Whereas Battese *et al.* (2004) applied mathematical programming, Huang *et al.* (2014) used the stochastic frontier model to estimate the metafrontier cost. The common underlying metafrontier cost function for all groups in the tth period is defined as $(f_t^M(X_{jit}))$, where the function is the same for all groups, $j = 1, 2, …, J$. By definition, the metafrontier $(f_t^M(X_{jit}))$ envelops all individual group frontiers $(f_t^j(X_{jit}))$, expressed as follows:

$$f_t^j(X_{jit}) = f_t^M(X_{jit})e^{-U_{jit}^M} \text{, j = 1, 2, …, J; i = 1, 2, …, } N_j \text{; t = 1, 2, …, T,} \qquad (5)$$

where $1 > U_{jit}^{-M} > 0$. Hence, $f_t^M(X_{jit}) \leq f_t^j(X_{jit})$ and the ratio of the jth group's cost frontier to the metafrontier is defined as TGR:

$$TGR_{it}^j = \frac{f_t^j(X_{jit})}{f_t^M(X_{jit})} = e^{-U_{jit}^M} \leq 1. \qquad (6)$$

It is construed that the technology gap is due to the choice of a particular technology according to both the economic and non-economic environments. Thus, the technology gap component in (4) is specific to group, DMU, and time. Moreover, TGR depends on the accessibility and extent of adoption of the available metafrontier cost technology.

At a given input level X_{jit}, a DMU's observed cost $f_t^j(X_{jit})$ relative to the metafrontier $f_t^M(X_{jit})$ consists of three components: TGR $TGR_{it}^j = \frac{f_t^j(X_{jit})}{f_t^M(X_{jit})}$, the DMU's cost-efficiency $CE_{it}^j = \frac{f_t^j(X_{jit})e^{-U_{jit}}}{f_t^j(X_{jit})} = e^{-U_{jit}}$,

and a random noise component $\frac{C_{jit}}{f_t^j(X_{jit})e^{U_{jit}}} = e^{V_{jit}}$. Based on (6), it is therefore defined as:

$$\frac{C_{jit}}{f_t^M(X_{jit})} = TGR_{it}^j \times CE_{it}^j \times e^{V_{jit}} \qquad (7)$$

The DMU's cost-efficiency with respect to the metafrontier cost efficiency (MCE_{jit}) is defined as:

$$MCE_{jit} = \frac{C_{jit}}{f_t^M(X_{jit})e^{V_{jit}}} = TGR_{it}^j \times CE_{it}^j \qquad (8)$$

The problems with the mixed approach of Battese *et al.* (2004) and O'Donnell *et al.* (2008) arise from using the mathematical programming technique and omitting the $f_t^j(X_{jit})$ error in estimating $\hat{f}_t^j(X_{jit})$. Consequently, the statistical properties of the metafrontier estimates in the second step are unknown. In contrast, Huang *et al.* (2014) used metafrontier stochastic frontier regression in the second step to estimate and consider the error of $f_t^j(X_{jit})$.

3.3. Economies of Scale and Scope

A bank's economies of scale can help show how banks manage their average costs relative to a proportional change in their outputs. Therefore, we investigate whether banks possess economies of scale and scope, and define the measure of economies of scale (SE) as:

$$SE = \frac{C^*(P,Y)}{\sum_{i=1}^{3} Y_i C_i^*(P,Y)} \qquad . \qquad\qquad (9)$$

If SE > 1, then a bank faces decreasing returns to scale, indicating it is experiencing diseconomies of scale. If SE = 1, then a bank is operating at constant returns to scale. If SE < 1, then a bank achieves increasing returns to scale, implying the larger the bank, the lower its operating costs.

Economies of scope exist when the total cost of a firm producing several outputs is lower than the sum of the costs to produce each output individually. In the case of a bank producing three outputs (Y_1, Y_2, and Y_3), as suggested by Mester (1996) the degree of economies of scope (SC) is estimated by:

$$SC = \frac{C^*(Y_1 - 2Y_1^m, Y_2^m, Y_3^m, P) + C^*(Y_1^m, Y_2 - 2Y_2^m, Y_3^m, P) + C^*(Y_1^m, Y_2^m, Y_3 - 2Y_3^m, P) - C^*(Y_1, Y_2, Y_3, P)}{C^*(Y_1, Y_2, Y_3, P)} . \qquad (10)$$

An estimate of SC > 0 indicates economies of scope and SC < 0 diseconomies of scope.

4. EMPIRICAL RESULTS

4.1. Data Source and Variable Definition

The data set used to determine the SFA efficiency consists of individual bank data sourced from unconsolidated statements in BankScope. Our sample includes all commercial banks in India, Thailand, Bangladesh, Malaysia, and Mongolia, with reference to the World Bank (WB)'s regulation and supervision database developed by Barth *et al.* (2004; 2008). Our sample comprises 141 commercial banks from these five developing Asian countries, about which complete data are available for the period between 2000 and 2010.

The input factors are deposits, labor, and fixed assets and the output variables loans, investments, and operating income. Table 1 lists the definitions and summary statistics for these variables, which, because they are nominal values, are converted into real variables using the consumer price index.

Table-1. Variable Definitions and Descriptive Statistics

Variable		Description	India		Thailand		Bangladesh		Malaysia		Mongolia	
			Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Total Cost(TC)		Interest Cost + Labor Cost + Other Operating Costs	542,138	1,223,285	293,539	417,796	54,663	73,279	4,374,045	6,994,227	10,862	18,231
Input	Input(X_1)	Deposits	9,028,311	17,435,864	8,762,937	10,774,485	724,584	939,203	5,980,861	9,249,898	165,688	236,058
	Input(X_2)	Labor	11,199,606	21,719,511	10,537,552	12,668,521	864,652	1,145,447	7,141,046	11,069,054	243,465	341,877
	Input(X_3)	Fixed Assets	102,396	173,560	181,868	254,842	11,472	19,815	40,432	59,114	6,805	6,924
	Price of Funding(P_1)	Interest Cost ÷ Deposits	0.083	0.159	0.034	0.040	0.063	0.034	0.030	0.023	0.077	0.058
	Price of Labor(P_2)	Labor Cost ÷ Labor	0.010	0.006	0.009	0.006	0.011	0.004	0.006	0.004	0.013	0.011
	Price of Capital(P_3)	Other Operating Costs ÷ Fixed Assets	1.120	1.543	1.330	1.410	1.460	2.929	11.986	61.289	0.764	0.488
Output	Output(Y_1)	Loans	6,534,137	12,890,908	7,460,475	8,994,664	575,736	690,143	4,374,045	6,994,227	101,802	133,045
	Output(Y_2)	Investments	10,020,273	19,416,181	9,715,474	11,723,305	729,680	884,400	5,806,101	9,206,502	202,251	299,605
	Output(Y_3)	Operating Income	135,838	292,231	93,289	147,431	21,602	30,937	68,099	113,417	4,049	8,626

Unit: US thousands; people, %

Source: Bureau van Dijk (BvD) publishes the Bank Scope database.

The following subsections explain the variables in the inefficiency model.

4.1.1. Capital Regulation

Chortareas et al. (2012) pointed out that capital adequacy rules specify the amount of capital each bank should hold. Insufficient capital increases the risk of bank failure, while excessive capital imposes unnecessary costs on banks and their customers, which adversely affects the efficiency of the banking system. In this study, whether the capital adequacy ratio complies with the minimum capital requirement is used as the proxy (dummy) variable, which is set to 1 if the ratio is compliant and 0 otherwise. Pasiouras (2008); Fiordelisi et al. (2011); Chortareas et al. (2012) and Haque and Brown (2017) have shown that capital regulation can improve banking efficiency, because higher capital requirements could lower their risk-taking behavior (Blum, 1999); thus, improving information availability, increases efficiency in turn. However, Pasiouras et al. (2009) and Sassi (2013) found that capital regulation led to lower profit efficiency, because banks substitute loans with less risky assets.

4.1.2. Bank Capitalization

The level of bank capitalization, represented by the equity to total assets ratio, illustrates the increased motivation of shareholders to monitor management and the increased capacity to generate shareholder value (Lensink et al., 2008). Indeed, higher capitalization helps alleviate agency problems between managers and shareholders (Mester, 1996) and Goddard et al. (2004) and Iannotta et al. (2007) demonstrated that capital ratio is associated with positive profitability.

4.1.3. Intermediation

We use NIM—interest income minus interest expense divided by interest-earning assets—as a proxy for the intermediation variable (Barth et al., 2006). As NIM measures the gap between what the bank receives from loans and what the bank pays to depositors, a high NIM may indicate inefficient intermediation, which is reflected in a higher interest rate spread between lending and savings rates (Beck et al., 2010).

4.1.4. Market Concentration

We use the Herfindahl–Hirschman Index (HHI)—the sum of the square of the market shares (assets) of individual banks in each country—as a proxy for market concentration, with a higher value indicating greater monopoly power. We expect greater market concentration to be negatively associated with banking efficiency: potentially, fewer banks dominating the market can inhibit competition and exert an adverse effect on efficiency (Demirguc–Kunt et al., 2004).

4.2. Metafrontier Estimation

Table 2 shows the empirical results of the metafrontier cost function.

Table-2. Empirical Results of the Metafrontier Cost Function

Variables	Coefficient		Standard Error	t-ratio
Constant	10.4751	***	0.1142	91.7582
$\ln Y_1$	-0.2127	***	0.0226	-9.4003
$\ln Y_2$	-0.2482	***	0.0189	-13.1572
$\ln Y_3$	-0.6392	***	0.0508	-12.5805
$\ln(P_1/P_2)$	0.1892	***	0.0452	4.1821
$\ln(P_3/P_2)$	2.1361	***	0.0533	40.0869
$\tfrac{1}{2} \times (\ln Y_1)^2$	-0.7051	***	0.0261	-26.9823
$\tfrac{1}{2} \times (\ln Y_2)^2$	0.2909	***	0.0134	21.7681
$\tfrac{1}{2} \times (\ln Y_3)^2$	0.5341	***	0.0706	7.5613
$\ln Y_1 \times \ln Y_2$	0.3990	***	0.0235	16.9706
$\ln Y_1 \times \ln Y_3$	0.1929	***	0.0302	6.3888
$\ln Y_2 \times \ln Y_3$	0.1633	***	0.0166	9.8219
$\tfrac{1}{2} \times (\ln(P_1/P_2))^2$	-1.0263	***	0.1174	-8.7432
$\tfrac{1}{2} \times (\ln(P_3/P_2))^2$	-0.1418	***	0.0270	-5.2593
$\ln(P_1/P_2) \times \ln(P_3/P_2)$	-0.3982	***	0.0741	-5.3752
$\ln Y_1 \times \ln(P_1/P_2)$	-0.4324	***	0.0559	-7.7328
$\ln Y_1 \times \ln(P_3/P_2)$	0.1386	***	0.0433	3.2032
$\ln Y_2 \times \ln(P_1/P_2)$	0.1220	***	0.0461	2.6446
$\ln Y_2 \times \ln(P_3/P_2)$	0.3177	***	0.0363	8.7581
$\ln Y_3 \times \ln(P_1/P_2)$	-2.2357	***	0.1584	-14.1157
$\ln Y_3 \times \ln(P_3/P_2)$	-1.6912	***	0.0839	-20.1650
Environment variables				
Constant	0.5670	***	0.0709	7.9987
Capital regulation	0.1035		0.0654	1.5821
Bank capitalization	-1.0660	***	0.0852	-12.5110
Intermediation	-0.6837	**	0.1034	-6.6143
Market concentration	2.4915	***	0.1666	14.9584
$\sigma_u^2 + \sigma_v^2$	0.3115	***	0.0172	18.1509
Gamma	0.3271	***	0.0434	7.5449
Log likelihood function			-1060.904	

Note: Y_1, loans; Y_2, investment; Y_3, non-interest income; P_1, price of funding; P_2, price of labor; P_3, price of capital. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

4.2.1. Capital Regulation

Although official capital adequacy regulations play a crucial role in aligning the incentives of shareholders with depositors and other creditors, leading to more cautious lending and better banking performance (Keeley and Furlong, 1990; Kaufman, 1992; Barth *et al.*, 2006) our results reveal that there is no statistically significant relationship between the minimum capital requirement and banking efficiency: the regulations exert no considerable influence on banking supervision.

4.2.2. Bank Capitalization

The results in Table 2 show that bank capitalization has a positive and statistically significant effect on banking efficiency, which confirms that higher capital ratios are related to greater efficiency and supports the argument that higher capitalization helps alleviate agency problems between managers and shareholders (Mester, 1996; Kalyvas and Mamatzakis, 2014): shareholders have greater incentives to monitor management's performance and ensure their bank operates efficiently (Eisenbeis *et al.*, 1999).

4.2.3. Intermediation

The empirical results for intermediation reveal a significantly positive relationship with cost-efficiency. In the five developing Asian countries, the higher the interest rate spread, the greater the profit and cost-efficiencies, which implies that inefficient intermediation increases the cost-efficiency of banks in developed countries.

4.2.4. Market Concentration

In these developing Asian countries, the empirical results show that the higher the market concentration, the lower the cost-efficiency of a bank (Dabla-Norris and Holger, 2007) which means that it is difficult to compete where there is high market concentration. This differs from the general conclusion that in developed countries a higher market concentration benefits banking (Jeon and Miller, 2002; Pilloff and Rhoades, 2002). However, whereas the competitive market provides the incentive for bank managers to improve performance, as well as information on appropriate incentive schemes, the lack of competition allows a relaxation in efforts to perform better (Berger and Hannan, 1989; Allen and Gale, 2000).

4.3. Technology Gap Ratio and Meta-Cost Efficiency

As shown in Table 3 and Figure 1, the average CEs for each country range from 0.6988 to 0.8974. Malaysia's cost-efficiency is the lowest, with the other countries averaging over 0.8. Further analysis of their TGR and MCE provides estimates of the efficiency values for each country, which are all at the same metafrontier cost function. Table 3 and Figure 2 show that the estimated TGR lies between 0.3644 and 0.7671. The average TGR value of Thailand is the lowest at 0.4245, whereas India's is the highest at 0.7527.

Table-3. Summary Statistics for CE, TGR, and MCE

Country/Statistic	Mean	Minimum	Maximum	Std. Dev.
India				
CE	0.8928	0.8708	0.9084	0.0138
TGR	0.7527	0.7416	0.7671	0.0072
MCE	0.6715	0.6499	0.6892	0.0130
Thailand				
CE	0.8328	0.7652	0.8706	0.0331
TGR	0.4608	0.4392	0.5003	0.0188
MCE	0.3852	0.3614	0.4130	0.0162
Bangladesh				
CE	0.8974	0.8662	0.9196	0.0174
TGR	0.5661	0.5396	0.5988	0.0170
MCE	0.5123	0.4844	0.5377	0.0125
Malaysia				
CE	0.6988	0.6791	0.7234	0.0128
TGR	0.5032	0.4742	0.5410	0.0218
MCE	0.3531	0.3409	0.3743	0.0102
Mongolia				
CE	0.8678	0.8053	0.9811	0.0500
TGR	0.4927	0.3644	0.5676	0.0532
MCE	0.4245	0.3049	0.4740	0.0490
All countries				
CE	0.8379	0.6791	0.9811	0.0160
TGR	0.5551	0.3644	0.7671	0.0174
MCE	0.4693	0.3049	0.6892	0.0163

Note: CE, cost-efficiency; TGR, technology gap ratio; MCE, metafrontier cost-efficiency.

It is obvious from Figure 2 that the TGR for Indian banks (0.7527), and thus their technical performance, is greater than that in Thailand, Malaysia, Bangladesh, and Mongolia. The MCE for the five countries ranges from 0.3409 to 0.6892, as shown in Table 3 and Figure 3. From the average MCEs, the highest is again in India at 0.6715, while the lowest is in Malaysia.
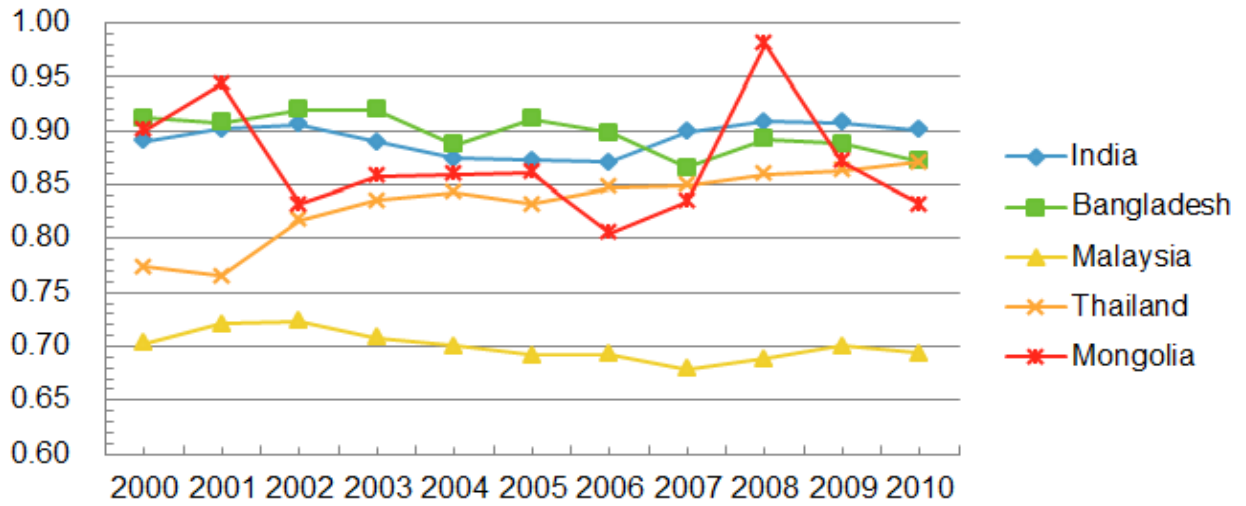
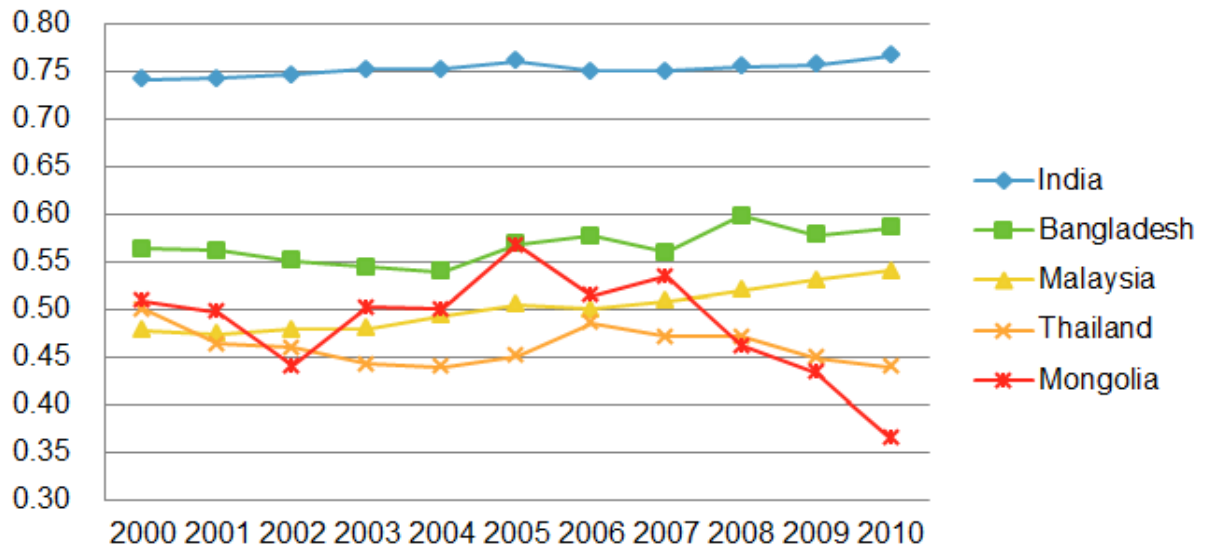**Figure-1.** CE for Banks

Note: CE, cost-efficiency.

Figure-2. TGR for Banks
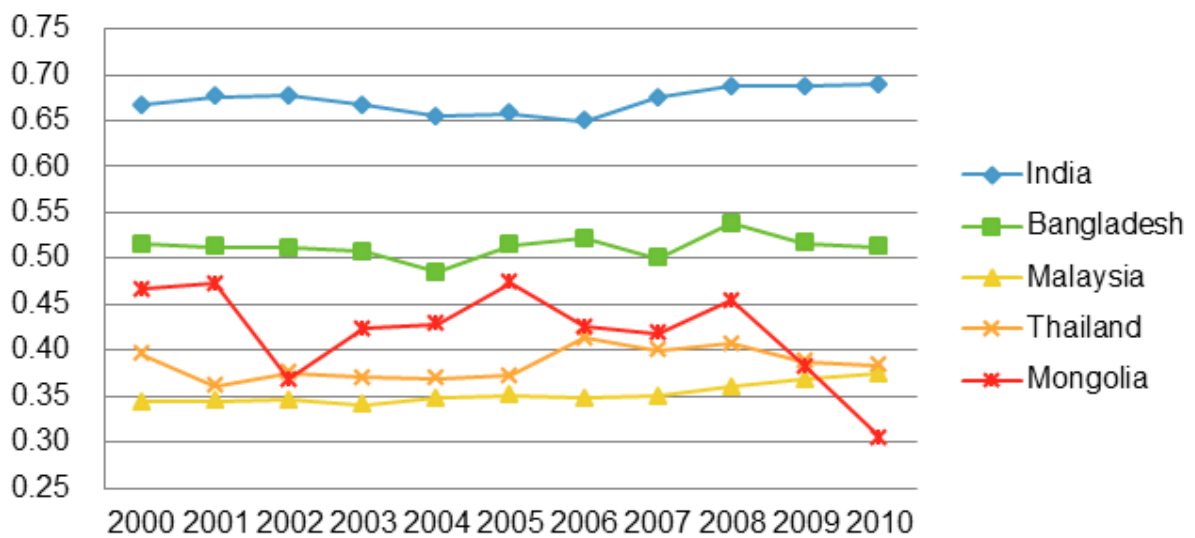
Note: TGR, technology gap ratio.

Figure-3. MCE for Banks

Note: MCE, metafrontier cost-efficiency.

4.4. Economies of Scale and Scope

Table 4 indicates the average values for the economies of scale and scope. The economies of scale average for Indian banks is 1.0060, indicating constant returns to scale. The averages for banks in Thailand, Bangladesh, and Malaysia are 0.5354, 0.3586, and 0.4198, respectively, showing increasing returns to scale, larger size, and lower operating costs. For Mongolian banks, the average is 2.5467, revealing decreasing returns to scale and diseconomies of scale.

The economies of scope averages for Malaysian, Thai, and Indian banks are 5.1060, 1.2928, and 0.3696, respectively, implying scope economies and demonstrating that diversification in financial products reduces costs. However, the averages for Bangladeshi and Mongolian banks are −0.8319 and −0.4212, respectively, indicating diseconomies of scope.

Table-4. Estimated Economies of Scale and Scope

Country	Economies of Scale	Economies of Scope
India	1.0060	0.3696
Thailand	0.5354	1.2928
Bangladesh	0.3586	−0.8319
Malaysia	0.4198	5.1060
Mongolia	2.5467	−0.4212

5. CONCLUSION

This study uses the stochastic frontier approach (SFA) of Battese and Coelli (1995) and stochastic metafrontier function (SMF) of Huang et al. (2014) to explore the different effects of financial regulations on the cost-efficiency of banking in India, Thailand, Bangladesh, Malaysia, and Mongolia from 2000 to 2010. The findings show that banking efficiency is not significantly influenced by minimum capital requirements; however, higher capitalization helps to alleviate agency problems between managers and shareholders, and provides shareholders with greater incentives to monitor management's performance and ensure their bank operates efficiently. The empirical results also show that the higher the interest rate spread, the greater the profit and cost-efficiencies, and the higher the market concentration, the lower the cost-efficiency of banks in developing Asian countries.

For banking supervision, the estimated SMF under the metafrontier cost function of the five countries, whether considering TGR or MCE, reveals Indian banks have the best results at 0.7527 and 0.6715, respectively, while Thailand has the lowest TGR value at 0.4608 and Malaysia the lowest MCE value at 0.3531.

The outcome for economies of scale and scope reveal that Thailand, Bangladesh, and Malaysia have increasing returns to scale, implying that the larger the bank, the lower the operating costs. On the other hand, Bangladeshi and Mongolian banks have diseconomies of scope, indicating that expanding scope does not enhance but diminishes the value of businesses in their portfolios.

Notes

1. The US Banking Act of 1933 established controls over deposit interest rates of commercial banks; later, in 1966, controls were extended to depository institutions, for which all member banks of the Federal Reserve System had to apply Regulation Q. However, given financial innovations and fluctuations in the economic and financial environment, the Depository Institutions Deregulation and Monetary Control Act (often abbreviated to DIDMCA) was passed in March 1980 to accelerate the liberalization of interest rates. Actions were subsequently taken, from the late 1980s to early 1990s, to accelerate the relaxation of branch restrictions among states: the Riegle–Neal Interstate Banking and Branching Efficiency Act of 1994 and the Gramm-Leach-Bliley Act, also known as the Financial Services Modernization Act, of 1999, which allowed a single institution to act as a commercial and investment bank—in other words, a universal bank.

2. We use stochastic frontier analysis (SFA) rather than DEA because of its main advantage in allowing us to distinguish between inefficiency and other stochastic shocks in the estimation of efficiency scores (Yildirim and Philippatos, 2007).

3. As data on the number of employees are not available from the database, the price of labor is defined as total assets, the definition used by Huang *et al.* (2015).

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