



Article

Role of Bank Regulation on Bank Performance: Evidence from Asia-Pacific Commercial Banks

Zhenni Yang *, Christopher Gan and Zhaohua Li

Department of Financial and Business Systems, Faculty of Agribusiness and Commerce, Lincoln University, Christchurch 7647, New Zealand

* Correspondence: zhenni.yang@lincoln.ac.nz; Tel.: +64-21-183-4896

Received: 30 June 2019; Accepted: 3 August 2019; Published: 7 August 2019



Abstract: The banking industry is an essential financial intermediary, thus the efficient operation of banks is vital for economic development and social welfare. However, the 2008 global financial crisis triggered a reconsideration of the banking systems, as well as the role of government intervention. The literature has paid little attention to the banking industry in the Asia-Pacific region in the context of bank efficiency. This study employs double bootstrap data envelopment analysis to measure bank efficiency and examine the relationship between regulation, supervision, and state ownership in commercial banks in the Asia-Pacific region for the period 2005 to 2014. Our results indicate that excluding off-balance sheet activities in efficiency estimations lead to underestimating of the pure technical efficiency, while overestimating the scale efficiency of banks in the Asia-Pacific region. Cross-country comparisons reveal that Australian banks exhibit the highest levels of technical efficiency, while Indonesian banks exhibit the lowest average. Our bootstrap regression results suggest that bank regulation and supervision are positively related to bank technical efficiency, while state ownership is not significantly related to bank efficiency. Furthermore, our findings show that tighter regulation and supervision are significantly related to higher efficiency for small and large-sized banks.

Keywords: banks; efficiency; data envelopment analysis; Asia-Pacific; regulations

1. Introduction

Banking industries, as primary financial intermediaries, provides liquidity and payment services, transforms deposits into loans, and manages and monitors investment projects (Freixas and Rochet 2008). The efficient operation of banks not only enhances economic development, but also influences the income distribution of the economy (Barth et al. 2004). However, the 2008 Global Financial Crisis (GFC) provides evidence that banking industries are not always stable. Before the 2008 GFC, banking industries, especially those in the United States (US), were heavily involved in the real estate bubble and credit boom, through off-balance sheet (OBS) activities. The collapse of the banking industries in 2008 quickly spread to the global financial system (Kim et al. 2013).

In addition to the prevalent OBS activities (DeYoung and Torna 2013; Engle et al. 2014), inefficient regulation and supervision (Brunnermeier 2009) in the banking industries are among other possible reasons for the recently fragile financial system and massive economic turmoil. That GFC also triggered the reconsideration of the official interventions in the financial system (Cihak and Demirgüç-Kunt 2013). In practice, regulation and supervision define capital standards, set requirements for entry into the banking market, frame acceptable ownership structures, and provide business guidelines for the banking industries (Barth et al. 2013).

Compared to countries in other regions, most countries in the Asia-Pacific region have a bank-dominated financial system. Financial systems in the Asia-Pacific region have undergone

profound deregulation and privatisation since the 1970s. Following the deregulation, banking industries in the Asia-Pacific region have experienced rapid growth in loans and investments. After the 1997 Asian Financial Crisis (AFC), governments in the region implemented a series of structural changes (and reforms), both in the banking systems, and regulatory and supervisory mechanisms. Following the 2008 GFC, most countries in the Asia-Pacific region had fully implemented the Basel II Accord, and were in a better position to introduce Basel III Accord regulations ([International Monetary Fund 2013](#)).

There are two main rationales for the existence of bank regulation and supervision. Firstly, regulation and supervision can mitigate potential conflicts of interest and externalities in the banking system, and thereby benefit the banking industry and social welfare ([Kilinc and Neyapti 2012](#)). Secondly, regulation and supervision can maintain the stability of fragile banking systems and function as a safety net for the financial system ([Kroszner 1998](#)). However, regulation and supervision are associated with extra costs for the banking systems. It is also difficult to reach equilibrium between different regulatory rules ([Freixas and Rochet 2008](#)).

As another major tool of government intervention in the banking industry, state ownership has been widely observed in the banking industry globally. The degree of state ownership in banks depends on factors such as economic and financial development, property rights, and financial openness ([La Porta et al. 2002](#)). Theoretically, there are two views supporting government ownership in the financial markets: Development and political views. The development view contends that some financial markets are not sufficiently developed for banks to be functional. Therefore, governments need to participate in the financial institutions to enhance the country's financial and economic development ([Gerschenkron 1962](#)). In the political view, state ownership in the banking industry is a way for politicians to affect banks' decisions and achieve their political objectives. When the government owns the bank, it will allocate capital resource to its supporters and gain votes ([Shleifer and Vishny 1994](#); [Shleifer 1998](#)).

This paper investigates the impacts of the inclusion of OBS activities in bank efficiency measurement. Furthermore, we examine the relationship between bank regulation, supervision and state ownership with bank efficiency in the Asia-Pacific region. The remainder of the study is organised as the follows: Section 2 provides an overview of the Asia-Pacific banking industries; Section 3 reviews the related literature; Section 4 describes the data and methodology; Section 5 discusses the empirical results; and Section 6 concludes the paper.

2. Overview of Banking Industries in the Asia-Pacific Region

The banking system has dominated the financial system and has played a vital role in the economic development of the Asia-Pacific region over the previous two decades. Before the 1997 AFC, the Asia-Pacific region experienced financial deregulation and reforms, followed by rapid economic growth relative to the US and European countries. Throughout 1990 to 1996, the region experienced significant foreign capital inflow, high levels of domestic consumption, booming investments, and excessive credit expansion.

However, impotent regulation and supervision during the period of financial deregulation and reform exposed the system's weaknesses ([Fu et al. 2014](#)) in the region. Except for Australia, most economies in the region were severely affected by the 1997 AFC. More specifically, South Korea, Indonesia, Malaysia, the Philippines, and Thailand were directly affected, while Hong Kong, Singapore, and Japan were indirectly affected and experienced negative economic growth during this period. Following the 1997 AFC, governments in the region began a series of structural reforms and prudential regulatory policies to revive the economy and financial industry. Specifically, the supervisory authorities in the Asian region have contributed to the banks' better asset quality after the 1997 AFC ([Rosenkranz and Lee 2019](#)). In compliance with the more conservative regulatory policies, banks in the Asia-Pacific region have mostly increased their capital ratios ([Capannelli and Filippini 2010](#)). More surprisingly, the Asia-Pacific banking industry maintained a high return on assets (ROA) ratio during the 2008 GFC. Furthermore, the average ROA in the Asia-Pacific region was almost twice

that of the rest of the world, as of the end of 2014; this was largely contributed by the rapid growth of the Chinese and Indonesian banking sectors (McKinsey Company 2016).

3. Literature Review

3.1. Efficiency Measurement

Efficiency is a commonly used concept to describe a firm's performance. The basic idea of efficiency measurement is to compare the observed production to the optimal production which operates on the production frontier. Parametric and nonparametric approaches are often used to conduct the approximation of the frontier and efficiency estimation. Both approaches are benchmarking methods, which exploit the distance function between observed production and the production frontier. Among the various techniques stemming from these two approaches, the two most popular approaches employed in the banking literature are the stochastic frontier analysis (SFA) (a parametric approach) and data envelopment analysis (DEA) (a nonparametric approach) (Fethi and Pasiouras 2010).

3.2. Inclusion of Off-Balance Sheet Activities in Efficiency Estimation

Considering the expansion in banks' business scopes during development of the industry, researchers currently recognise the importance of incorporating the off-balance sheet (OBS) activities in bank efficiency estimations. While most studies directly include OBS activities into efficiency estimations (see for example, Drake 2001; Drake and Hall 2003; Radić et al. 2012; Sufian et al. 2012), only limited numbers of studies provide any justification for the inclusion of OBS activities in efficiency estimations (Rogers 1998; Mester 1996; Clark and Siems 2002; Lieu et al. 2005; Pasiouras 2008a; Lozano-Vivas and Pasiouras 2010, 2014). These studies provide ambiguous evidence on the impacts of OBS activities inclusion in bank efficiency measurement.

Rogers (1998) measured the efficiency of more than 10,000 commercial banks (including branches) in the US over the period 1991 to 1995. The author's results indicate that cost and profit efficiencies of commercial banks would both be underestimated when OBS activities are omitted. Similarly, Clark and Siems (2002) examined the impact of including OBS activities on US bank efficiency over the period 1992 to 1997. They concluded that OBS activities are useful for explaining variations in banks' costs and profits. The cost efficiency is higher with the inclusion of OBS activities, but their results demonstrate little changes in the profit efficiency measurement for the banks. Using the SFA approach, Lieu et al. (2005) measured the cost efficiency of the Taiwanese banking industry from 1998 to 2001. They found that omitting OBS activities would lead to underestimating a bank's cost efficiency by 55%. In a study of the Greek banking industry from 2000 to 2004, Pasiouras (2008b) found that bank cost efficiencies are not significantly affected by omitting OBS activities as an output.

Using large samples from multiple banking industries around the world, Lozano-Vivas and Pasiouras (2010, 2014) examined the impact of including OBS activities on cost efficiency, profit efficiencies, and Malmquist productivities measurements. They found mixed results. Lozano-Vivas and Pasiouras (2010) explored the cost and profit efficiency for 87 countries banks from 1999 to 2006 and found that cost efficiency would have been higher when considering OBS activities, while the results for profit efficiency were mixed. Using data from 84 countries over the period 1999 to 2006, Lozano-Vivas and Pasiouras (2014) estimated the Malmquist cost and profit productivity for banks. They found that bank profit productivity was higher with OBS activities, while cost productivity was not significantly affected. Moreover, their results suggested that the exclusion of OBS activities should jeopardise the regression results when examining the relationship between environmental factors and bank performance.

3.3. Bank Regulation and Supervision, and Bank Efficiency

Previous studies provide inconclusive evidence with regards to the relationship between regulation, supervision and bank performance using data from various countries or regions. As one of the first

studies at the international level, [Barth et al. \(2004\)](#) find that activity restrictions are negatively related to bank efficiency. While market discipline can significantly boost bank efficiency, capital regulation and supervision power are not significantly related to bank performance. In addition, that state ownership is negatively related to bank efficiency. In a study by [Barth et al. \(2004\)](#), bank efficiency was measured with net interest margin and overhead costs (that is, lower net interest margins and overhead costs indicating higher bank efficiency).

Using 715 banks from 95 countries in 2003, [Pasiouras \(2008a\)](#) found empirical evidence to support the implementation of three pillars in the Basel II Accord. The authors' result indicates a positive correlation between capital adequacy regulation, official supervisory power, and market discipline with bank technical efficiency. Furthermore, deposit insurance has no significant relationship with bank efficiency. They also found that government and foreign ownership were associated with lower bank efficiency. In [Chortareas et al.'s \(2012\)](#) study, however, market discipline was found to be negatively related to the European banks' technical efficiency.

After measuring both cost and profit efficiency for banks from 74 countries from 2000 to 2004, [Pasiouras et al. \(2009\)](#) concluded that both official supervision and market discipline were positively related to both efficiency measurement. Additionally, they found that capital regulation would increase cost efficiency while reducing profit efficiency during the period. In contrast, activity restrictions improved profit efficiency but reduced cost efficiency. However, [Lozano-Vivas and Pasiouras's \(2010\)](#) study revealed that supervisory power was negatively related to cost efficiency and positively related to profit efficiency based on a larger dataset from 1999 to 2006.

More recently, [Luo et al. \(2016\)](#) examined the profit efficiency of banks from 140 countries over the period 1999 to 2011, and found that capital regulation, market discipline, and activity restrictions had positive relationships with bank efficiency. However, official supervision power was negatively related to bank efficiency. Focusing on banks from African countries, [Triki et al. \(2017\)](#) suggested that the impacts of regulation and supervision on bank performance depend on the bank size and risks. While other regulatory policies show no significant impact, capital stringency is found to be positively related to large banks with low risks.

Rather than using individual regulatory policies, [Gardener et al. \(2011\)](#) created a comprehensive regulatory index to capture information of the three pillars in the Basel Accord in their study of East Asian banking industries. Their results suggest that bank regulation is negatively related to technical efficiency while positively related to allocative efficiency. Moreover, that those relationships are not significant for state-owned banks, suggesting that regulation and supervision do not impact the performance of state-owned banks.

3.4. State Ownership in the Banking Industry

Most previous studies provide empirical evidence which supports the "political view" of state ownership and argue that state ownership is related to less development in the banking industry ([Barth et al. 2001](#); [La Porta et al. 2002](#)); less profitability ([Micco et al. 2007](#); [Cornett et al. 2010](#); [Lin and Zhang 2009](#)); and lower profits and cost efficiency ([Berger et al. 2005](#); [Bonin et al. 2005](#); [Perera et al. 2007](#); [Margono et al. 2010](#)). However, a few studies find that state-owned banks are more efficient ([Gardener et al. 2011](#); [Wang et al. 2014](#); [Dong et al. 2014](#); [Berger et al. 2009](#)) than other types of banks and are related to higher stockholder value ([Hossain et al. 2013](#)). Other studies ([Barry et al. 2008](#)), however, find no significant difference between state-owned banks and privately-owned banks. [Micco et al. \(2007\)](#) argues that state-owned banks in developing countries have higher costs and lower profits, while those in developed countries have no significant difference in costs and profits. Some studies in the Indonesian banking industry suggest that state-owned banks are found to be less efficient ([Perera et al. 2007](#); [Margono et al. 2010](#); [Shaban and James 2018](#)).

In contrast with the previous argument that state ownership impedes bank performance, [Gardener et al. \(2011\)](#) suggest that state-owned banks in developing Asian countries are more efficient than other types of banks. [Hossain et al. \(2013\)](#) also notes that state ownership is a desirable

government intervention mechanism used to reduce the negative impact on shareholder value in the Asia-Pacific banking industry. Empirical evidence revealed the better performance of China’s four largest state-owned banks (Wang et al. 2014; Dong et al. 2014; Tan and Anchor 2017) over other banks in China. After estimating bank efficiency in Hong Kong, Indonesia, Korea, Malaysia, the Philippines, and Thailand, Barry et al. (2008) found that state-owned banks were not significantly different from privately-owned banks.

4. Data and Methodology

4.1. Data Sources

The bank-level financial data used in this study are comprised of data from unconsolidated statements of individual banks taken from the BvD Bankscope database. When unconsolidated statements are not available, consolidated statements are used instead. Only active commercial banks in Australia, China, Hong Kong, Indonesia, Japan, New Zealand, Singapore, and Thailand were used as sample banks in this study. To capture the overall banking industry characteristics, observations with less than three consecutive years of available data were omitted. Therefore, the sample data decreased from 5610 to 3749 observations for 544 banks. Due to the data validation requirements for DEA approaches, observations with missing, zero, or negative values in the inputs or outputs variables were dropped. As a result, a total sample of 2186 bank-year observations was obtained.

Data on bank regulation and supervision was obtained from the World Bank (2007, 2011). Considering that there were changes in bank regulatory and supervisory policies in most countries following the 2008 GFC, regulation and supervision data from the 2007 survey were used for the period 2005 to 2008. Those regulatory and supervisory data obtained from the 2011 survey were used for the period 2009 to 2014. Bank ownership data were constructed using ownership data provided in the BvD Bankscope database. Other country-level data was obtained using the Global Financial Development Database and World Governance Indicators Database. Appendix A Table A1 provides details of the definition and source of each variable used in this study.

4.2. Efficiency Estimation: Bootstrap DEA Approach

Similar to the conventional benefit/cost theory, the fundamental idea of efficiency measurement is to estimate a ratio of weighted outputs to weighted inputs for each decision-making unit (DMU) (Cook and Seiford 2009). In the efficiency estimation, banks operating on the production frontier are the best-practice banks with efficiency scores of one. Those operating away from the frontier are considered to be inefficient, with efficiency scores less than one. Depending on the distance from the sample banks to the frontier, the DEA approach is employed to estimate relative efficiencies ranging from 0 to 1 (Cook and Seiford 2009) for all individual banks.

Assume there are I banks in the sample data; each bank uses N inputs to produce M outputs. The input X_i for the i -th bank is an $N \times 1$ vector and the output Y_i is an $M \times 1$ vector for the i -th bank. Thus, the production set for bank i can be denoted as (X_i, Y_i) . To measure the input-orientated technical efficiencies for bank i , the constant return to scale (CRS) model solves the following linear programming problem as in Equation (1):

$$\begin{aligned} & \min_{\theta, \lambda} \theta, \\ & \text{s.t. } \theta X_i - X\lambda \geq 0, \\ & \quad -Y_i + Y\lambda \geq 0, \\ & \quad \lambda \geq 0 \end{aligned} \tag{1}$$

where θ is a scalar, and λ is a vector of constant. The efficiency estimated using Equation (1) is the overall technical efficiency.

After taking various external restrictions and influences into consideration, and assuming that there exists scale inefficiency as well as technical inefficiency in the banks during the production

process, the variable return to scale (VRS) model can be used to separate the technical inefficiency into pure technical inefficiency and scale inefficiency. To estimate pure technical efficiency for bank i , Equation (2) solves the linear programming problems:

$$\begin{aligned} & \min_{\theta, \lambda} \theta, \\ & \text{s.t. } \theta X_i - X\lambda \geq 0, \\ & \quad -Y_i + Y\lambda \leq 0, \\ & \quad e\lambda = 1 \\ & \quad \lambda \geq 0 \end{aligned} \tag{2}$$

where θ is a scalar, λ is a vector of constant, and e is an $I \times 1$ vector of ones.

The VRS model measures bank efficiency using a benchmark of similar-sized bank groups (Coelli et al. 2005). After excluding the impact of scale inefficiency, the technical efficiencies estimated using the VRS model are greater or equal to those estimated through the CRS model (Pasiouras 2008a) scale efficiency (SE) can be calculated as:

$$SE = \frac{TE_{CRS}}{PTE_{VRS}} \tag{3}$$

To deal with the issue of asymptotic distribution of estimated efficiency, Simar and Wilson (2000, 2007) proposed a smoothed bootstrapping DEA model to provide a more reliable interpretation of efficiency scores.

To consider the distinctive production opportunities for banks operating in different countries, O'Donnell et al. (2008) introduced the idea of meta-frontier for firms operating in different groups and facing various circumstances. The meta-frontier production possibility set T contains all the feasible input-output combinations for banks from all different groups, which can be expressed in a simple function, as:

$$T = \{(X, Y) | X \geq 0, Y \geq 0, X \text{ can produce } Y\} \tag{4}$$

The input-orientated efficiency score, which gives the maximum amount of input reduction for bank i is defined as meta-frontier technical efficiency (MTE). Assuming there are K ($K > 1$) countries in the sample, the technical efficiency for bank i in country k can be defined as group technical efficiency (GTE). Specifically, the technology gap ratio (TGR) for bank i in country k is defined as:

$$TGR_k^i(X_i, Y_i) = \frac{MTE(X_i, Y_i)}{GTE_k(X_i, Y_i)} = \frac{\theta}{\theta^k} \tag{5}$$

when TGR_k^i equals 1, the group-frontier is tangent to the meta-frontier. In other words, the larger the TGR_k , the more advanced the technology adopted by banks in country k .

Based on recent literature, our study employed the intermediation approach for input and output selection. Additionally, to analyse the impact of the inclusion of OBS activities, we estimated bank efficiency using four models with different input and output selections and examined whether the incorporation of OBS activities significantly affect bank efficiency measurements in the Asia-Pacific region (see Table 1). To capture the impact of OBS activities on efficiency estimations, “off-balance sheet items” were considered as an additional output to describe the aggregation of guarantees, acceptances and documentary credits, committed credit facilities, managed securitised assets, other exposure to securitisations, and other bank contingent liabilities. Additionally, “loan loss provisions” were also considered to be one of the inputs which indicate problem loans in the banking industry, following Charnes et al. (1990); Altunbas et al. (2000); Drake and Hall (2003); Pasiouras (2008b); and Hall et al. (2012)’s studies.

After obtaining four sets of efficiencies using 4 different models, we employed the Kruskal-Wallis test to examine if the differences between Models 1 and 2, and Models 3 and 4 were significantly different from zero. Furthermore, we used the Skillings-Mack test to test the rankings of the efficiencies

from 4 Models. All of the efficiency estimates are bias-corrected using the Bootstrap DEA approach following Simar and Wilson (2007).¹

Table 1. Input and output specifications for Models 1 to 4.

Model 1	Model 2	Model 3	Model 4
Inputs	Inputs	Inputs	Inputs
Fixed Assets Total Deposits Noninterest Expenses	Fixed Assets Total Deposits Noninterest Expenses	Fixed Assets Total Deposits Noninterest Expenses Loan Loss Provision	Fixed Assets Total Deposits Noninterest Expenses Loan Loss Provision
Outputs	Outputs	Outputs	Outputs
Loans Other Earning Assets	Loans Other Earning Assets Off-balance Sheet Items	Loans Other Earning Assets	Loans Other Earning Assets Off-balance Sheet Items

Source: Adapted from Pasiouras (2008b).

4.3. Bootstrap Truncated Regression Model

To measure the impact of regulation, supervision, and state ownership on bank efficiency, the bootstrap truncated regression model was employed using bias-corrected bank efficiency $\hat{\theta}$ as the dependent variable. Three bias-corrected efficiency measurements were used in the regression model. Specifically, pure technical efficiency (PTE) was used to measure bank efficiency by using minimum inputs to produce a given level of outputs; scale efficiency (SE) was used to measure the efficiency of exploiting the optimal operating scale, and the technology gap ratio (TGR) was used to measure the gap between technology in one country to the best production technology in the Asia-Pacific region. The regression models are specified as follows:

$$PTE_{k,i} = \beta_0 + \beta_1 * REG_k + \beta_2 * Ownership_{k,i} + \beta_3 * Bank_{i,k} + \beta_4 * Country_k + \beta_5 * YEAR Dummy + \beta_5 * country Dummy + \varepsilon_{k,i} \tag{6}$$

$$SE_{k,i} = \beta_0 + \beta_1 * REG_k + \beta_2 * Ownership_{k,i} + \beta_3 * Bank_{i,k} + \beta_4 * Country_k + \beta_5 * YEAR Dummy + \beta_5 * country Dummy + \varepsilon_{k,i} \tag{7}$$

$$TGR_{k,i} = \beta_0 + \beta_1 * REG_k + \beta_2 * Ownership_{k,i} + \beta_3 * Bank_{i,k} + \beta_4 * Country_k + \beta_5 * YEAR Dummy + \beta_5 * Country Dummy + \varepsilon_{k,i} \tag{8}$$

where $PTE_{k,i}$ denotes the bias-corrected pure technical efficiency for bank i in country k , $SE_{k,i}$ denotes the bias-corrected scale efficiency for bank i in country k ; $TGR_{k,i}$ denotes the bias-corrected technology gap ratio for bank i in country k . The independent variables are REG_k is a vector of bank regulation and supervision indicators in country k ; $Ownership_{k,i}$ is a dummy variable, which equals 1 when the bank is classified as state-owned; $Bank_{i,k}$ is a vector of bank-specific characteristics for bank i in country k , and $Country_k$ is a vector of country-specific characteristics for country k ; $YEAR Dummy$ is the year dummy variable from 2005 to 2014; $Country Dummy$ is the country dummy variable for the sample countries; $\varepsilon_{k,i}$ is the error term.

4.3.1. Bank Regulation and Supervision Variables

Together with activity restrictions, the three pillars of the Basel Accord II were used as regulation and supervision variables in the regression models. As discussed in the introduction, the three pillars are capital requirements, official supervision power and market discipline. Activity restrictions in the banking industry were also included to capture restrictions imposed on non-bank activities in

¹ More methodology descriptions can be found in the study of Simar and Wilson (2007).

the Asia-Pacific banking sectors. The four indicators of bank regulation and supervision are denoted as capital regulation CAP_k , official supervisory power $SPPOWER_k$, market discipline $MKDSPL_k$, and activity restrictions $ACRS_k$. Bank regulation and supervision data are obtained primarily from the Bank Regulation and Supervision Survey (Barth et al. 2007, 2012).

Based on Barth et al.'s (2001, 2007, 2008, 2012) descriptions, regulation and supervision variables are constructed through assigning "1" or "0" to several survey questions, where regulation and supervision authorities from various countries give answers of "yes" or "no".²

CAP_k was the index of capital regulation to measure the initial and overall capital requirements for banks in country k . This index was constructed using answers from five survey questions. The range of the capital requirement was from 0 to 7. A higher value indicates more stringency in the country's capital regulation.

$SPPOWER_k$ assessed the extent of official supervisory power to oversee, monitor, and discipline managers, directors, and auditors of banks in country k . Fourteen questions were surveyed to obtain the value of supervisory power. Variables ranged from 0 to 14 for each country. Similar to capital requirements, higher values show stronger supervisory power from regulatory authorities.

$MKDSPL_k$ measures information disclosure to shareholders, auditors, and the public, and whether any credit ratings are required by regulatory authorities for banks in country k . There were seven questions for this variable. Therefore, the value of market discipline ranged from 0 to 7. A higher value indicates a more informative and transparent banking industry.

$ACRS_k$ was the proxy of non-bank activity restrictions in real estate investment, insurance underwriting and selling, brokering and dealing securities, and all businesses of mutual fund industries in country k . For each category of activities, there were four answers: 1 (unrestricted), 2 (permitted); 3 (restricted); and 4 (prohibited). Thus, the value of $ACRS_k$ ranged from 0 to 12. A higher value of activity restriction indicates more restrictions on nonbank activities in the banking industry.

4.3.2. State Ownership

The variable $Ownership_{k,i}$ was used to examine the relationship between bank ownership and efficiency. Historical ownership data for each sample bank was obtained from the BvD Bankscope database. The global ultimate ownership (GUO) of banks and historical information of direct owners were considered when constructing the variable. Since 20% of the ownership is typically sufficient to have control rights in the banks' operation decisions (La Porta et al. 1999), the benchmark of 20% was used in this study to identify whether the government had control rights. For each bank, shareholders with shares of more than 3% in the bank were considered each year. If the shareholder was a central government, local government, or sole state-owned enterprise in country k , the shareholder was regarded as the government. The dummy variable $Ownership_{k,i}$ equaled one when the aggregate ownership of government in bank i of country k was greater than 20%. Similarly, we also identified foreign-owned banks for comparison. A bank was identified as foreign-owned when a single foreign shareholder owned more than 20% of the bank share. If the bank was neither state-owned nor foreign-owned, it was classified as a privately-owned bank.

4.3.3. Control Variables

To control the impact of other bank-specific characteristics on bank efficiency, this study included a set of bank-specific variables $Bank_{i,k}$ in the regression models. The bank-specific variables were $Banksize_{i,k}$; $EQTA_{i,k}$; $OBSTA_{i,k}$; $LLPTL_{i,k}$; $LIQTA_{i,k}$.

$Banksize_{i,k}$ is calculated as the logarithm of total assets to capture bank scale characteristics. $EQTA_{i,k}$ is proxied as the ratio of total equity divided by total assets, to control the level of capitalisation in banks. The other three variables are used to capture three types of risks in banks. The first variable

² The World Bank Regulatory and Supervisory survey questions are available upon request.

is $OBSTA_{i,k}$ is calculated as off-balance sheet items divided by total assets. A higher $OBSTA_{i,k}$ value suggests higher risks accompanied by a higher ratio of off-balance sheet activities. The second variable, risk proxy $LLPTL_{i,k}$ is used to capture credit risk, calculated as loan loss provisions over total loans. A higher $LLPTL_{i,k}$ value indicates a higher bank credit risk. The last risk measurement is $LIQTA_{i,k}$, which controls bank liquidity risk levels. $LIQTA_{i,k}$ is calculated as liquid assets over total assets. A higher $LIQTA_{i,k}$ value indicates lower liquidity risk in bank i in country k .

Except for bank-specific variables, country-specific variables were also included in our regression models to account for variations in bank operating environments. We considered five country-level variables: Real GDP growth (GDP_growth_k), inflation rate (INF_k), concentration (HHI_k), banking industry development ($PrCrGDP_k$), and institutional governance environment INS_ENV_k . GDP_growth_k is measured as the annual growth rate of GDP to control for macroeconomic conditions of the country. Additionally, inflation INF_k is measured by the annual rate of the implicit GDP deflator.

Finally, three remaining variables were used to capture the characteristics of the countries' banking industries. The first variable is concentration (Herfindahl Hirschman Index-HHI). HHI_k is calculated as the sum of the square of deposit shares for each bank in all banks of that country. The $PrCrGDP_k$ describes the level of bank claims to the private sector to GDP, which is used to capture the intermediation activities of the banking industry in one country (Pasiouras 2008a). The last variable, institutional governance indicator INS_ENV_k is used to control the institutional environment for countries. Initially, there are six dimensions of governance environment: Voice and accountability (*Voice*), political stability and absence of violence/terrorism (*Stability*), government effectiveness (*Gov_Eff*), regulatory quality (*Reg_Qua*), the rule of law (*Rule_Law*), and control of corruption (*Corruption*). Each of these variables ranges between -2.5 and 2.5 . Since these six variables are highly correlated, we employed principal component analysis to create a new variable INS_ENV_k to measure the overall governance environment of each country.

5. Empirical Results

5.1. Descriptive Statistics

Table 2 shows the mean and standard deviation values of each input and output variable for efficiency estimations, from 2005 to 2014. All of the bank data were obtained from the BvD Bankscope database, and data have been adjusted using the GDP deflator in 2005. Table 3 provides the descriptive statistics of the regression models' variables for the full sample data over the period 2005 to 2014. The pairwise correlation coefficients between the independent variables are shown in Appendix A Table A2. Based on the correlation matrix, the absolute values of most of the correlation coefficients are smaller than 0.3 and the maximum absolute value of the correlation coefficients is less than 0.7. Thus, multicollinearity was not a major concern in our regression models.

Table 2. Descriptive statistics of the inputs and outputs of banks in the Asia-Pacific region (2005–2014).

Variables	Mean	SD	Max	Min
Inputs				
Total Deposits	86,068.17	279,580.74 *	3,368,189.83	23.11
Fixed Assets	709.95	2,472.14	32,567.41	0.07
Noninterest Expenses	896.90	2,698.78	31,232.88	0.90
Loan Loss Provisions	209.44	782.56	10,632.95	0.00
Outputs				
Loans	45,788.47	141,244.02	1,759,887.29	6.09
Other Earning Assets	30,315.82	107,021.11	2,247,399.26	9.06
Off-balance Sheet Items	13,047.35	43,863.62	537,704.05	0.00

Notes: All of the bank data are real value in million US dollars adjusted based on the GDP deflator in 2005 for each country from 2005 to 2010. Source: Calculated by the author using data from the BvD Bankscope database. * The large standard deviation value compared to mean value can be observed in the studies of Chortareas et al. (2013); Viverita and Ariff (2011), etc.

Table 3. Descriptive statistics of regression model variables (2005–2014).

Variables	Mean	SD	Max	Min
Regulation and Supervision				
CAP	3.7683	1.7702	5	1
SPPOWER	11.7669	1.1598	14	7
ACRS	8.1163	2.0572	12	3
MKDSPL	5.3054	0.5554	6	4
DEP_INS	0.7239	0.4472	1	0
Ownership				
STATE	0.1003	0.3004	1	0
Bank-specific				
BANKSIZE	16.6697	1.8822	21.9376	10.048
EQTA	0.0876	0.0747	0.81	0.0035
OBSTA	0.1591	0.3874	13.2399	0
LLPTL	0.0061	0.0082	0.0797	0
LIQTA	0.1594	0.1295	0.8454	0.0014
Country-specific				
GDP_growth (%)	3.9979	3.9893	15.2404	−5.4171
INF (%)	2.631	4.378	18.1498	−1.8957
HHI	0.1375	0.0784	1	0.064
PrCrGDP (%)	98.7247	37.2066	219.12	22.31
INST_ENV	−0.6172	2.1847	2.5613	−3.7848

Notes: Bank-specific variables and HHI were calculated using data from the BvD Bankscope database. Data for GDP_growth, INF, and PrCrGDP were obtained from the Global Financial Development Database. Data of INST_ENV is the result of the principal component analysis from 6 indicators of World Governance Indicators. Source: Regulation and supervision data are obtained from the [World Bank \(2007, 2011\)](#).

5.2. Bank Efficiency and Non-Traditional Activities

To examine the impact of including OBS activities on bank efficiency estimations, Table 4 presents the average TE (technical efficiency), PTE (pure technical efficiency), and SE (scale efficiency) scores of 4 different models relative to the meta-frontier. After bias-correction, the TE, PTE and SE estimates had smaller means and standard deviations, which supports [Fallah-Fini et al.’s \(2012\)](#) statement that banks appear to be efficient under traditional DEA approach, but might not be efficient using the bootstrap DEA approach. According to [Simar and Wilson \(2007\)](#) and [Fallah-Fini et al. \(2012\)](#), one possible reason for the existence of such a large bias is that there are not enough observations to construct the correct frontier.

Without considering the asset quality of the banking industry, the comparison between bank efficiency of Models 1 and 2 show that the average TE and PTE scores are higher after with the inclusion of OBS activities. However, the average SE score is lower after incorporating non-traditional activities. Similarly, compared to Model 3, the average TE and PTE estimates are higher, and the average SE estimates are lower in Model 4. To test whether differences in bank efficiencies were significantly different from zero, we followed [Lozano-Vivas and Pasiouras \(2010\)](#), and conducted the Kruskal-Wallis tests to compare between Models 1 and 2, as well as Models 3 and 4. The results are presented in Table 5.

³ Model 1 excludes both off-balance sheet (OBS) and LLP in the efficiency estimation; Model 2 includes OBS and excludes LLP in the efficiency estimation; Model 3 consists of the LLP but excludes the OBS in the estimation; Model 4 includes both OBS and LLP in the estimation.

Table 4. Average technical efficiency, pure technical efficiency, and scale efficiency of 4 efficiency estimation models.³

Efficiencies	Without Considering Risk		With Considering Risk	
	Model 1 Without OBS	Model 2 With OBS	Model 3 Without OBS	Model 4 With OBS
Panel A: Bootstrap DEA Approach				
TE	0.5735 (0.1233)	0.5824 (0.1206)	0.6067 (0.1371)	0.617 (0.1354)
PTE	0.8025 (0.1257)	0.8290 (0.1233)	0.8161 (0.1213)	0.8459 (0.1173)
SE	0.7196 (0.1290)	0.7074 (0.1250)	0.7689 (0.2478)	0.7322 (0.1334)
Panel B: Traditional DEA Approach				
TE	0.6337 (0.1376)	0.6481 (0.1392)	0.6725 (0.1609)	0.6891 (0.1609)
PTE	0.8453 (0.1346)	0.8748 (0.133)	0.863 (0.1323)	0.8936 (0.1282)
SE	0.7546 (0.1306)	0.7468 (0.1364)	0.8062 (0.265)	0.7738 (0.1461)

Notes: TE = overall technical efficiency; PTE = pure technical efficiency; SE = scale efficiency. Standard deviations are shown in the parenthesis. Models 1 to 4 use different inputs and outputs specifications (see Table 1). Source: Author’s calculations.

Table 5. Kruskal-Wallis test results for efficiencies with and without off-balance sheet (OBS) activities.

Efficiencies	Without Considering Risk		With Considering Risk	
	Model 1 Without OBS	Model 2 With OBS	Model 3 without OBS	Model 4 With OBS
Panel A: Bootstrap DEA Approach				
TE	chi-squared = 6.426 probability = 0.0112		chi-squared = 6.847 probability = 0.0089	
PTE	chi-squared = 112.760 probability = 0.0001		chi-squared = 165.241 probability = 0.0001	
SE	chi-squared = 10.380 probability = 0.0013		chi-squared = 4.106 probability = 0.0427	
Panel B: The Traditional DEA Approach				
TE	chi-squared = 11.130 probability = 0.0008		chi-squared = 11.881 probability = 0.0006	
PTE	chi-squared = 95.529 probability = 0.0001		chi-squared = 109.965 probability = 0.0001	
SE	chi-squared = 6.231 probability = 0.0126		chi-squared = 0.053 probability = 0.8175	

Notes: TE = overall technical efficiency; PTE = pure technical efficiency; SE = scale efficiency. Null hypotheses of the Kruskal-Wallis tests state that two efficiencies are the same and a small *p*-value suggests a rejection of the null hypothesis. Source: Author’s calculation.

Table 6 indicates that efficiency estimates from the four models were significantly different, based on the small *p*-values for PTE (Panel A), TE (Panel B), and SE (Panel C). Furthermore, based on the information from the ranking statistics (*W*SumCRank and *W*Sum/SE), we can confirm our observations in Table 4. Model 2 had higher average PTEs and TEs than those in Model 1, and Model 4 had higher PTEs and TEs than those in Model 3. In addition, after the inclusion of OBS activities, the SEs in Model 2 (Model 4) were lower than those in Model 1 (Model 3).

Table 6. Results of Skillings-Mack test for efficiency estimates for the four efficiency estimation models.

Models	Number of Observations	WSumCRank	Standard Error	WSum/SE
Panel A: Overall Technical Efficiency				
Model 1	2505	−3094.51	86.69	−35.7
Model 2	2505	−1266.47	86.69	−14.61
Model 3	2505	1326.88	86.69	15.31
Model 4	2505	3034.1	86.69	35
Skillings Mack = 2210.210				
<i>p</i> -value (No ties) = 0.0000				
Panel B: Pure Technical Efficiency				
Model 1	2505	−3004.66	86.69	−34.66
Model 2	2505	502.71	86.69	5.8
Model 3	2505	−510.46	86.69	−5.89
Model 4	2505	3012.41	86.69	34.75
Skillings Mack = 1857.871				
<i>p</i> -value (No ties) = 0.0000				
Panel C: Scale Efficiency				
Model 1	2505	256.39	86.69	2.96
Model 2	2505	−1742.07	86.69	−20.1
Model 3	2505	948.88	86.69	10.95
Model 4	2505	536.8	86.69	6.19
Skillings Mack = 428.050				
<i>p</i> -value (No ties) = 0.0000				

Notes: WSumCRank is the weighted sum of centred ranks. Standard Error: Standard error of the test. WSum/SE is the weighted sum of cantered ranks divided by the standard error. Smaller WSumCRank or WSum/SE indicates a lower rank among the models. Source: Author’s calculations.

Table 7 shows the average meta-frontier PTE score of 0.9039 for Australian banks was the highest, relative to the average level of other countries, followed by Hong Kong (0.8958) and Japan (0.8847). In contrast, Indonesian banks had the lowest average meta-frontier PTE estimate of 0.7312, which suggests that an average bank in Indonesia can reduce inputs by 26.88% compared to the most efficient banks in the Asia-Pacific region, to produce the same level of outputs.

Combining the information of group-frontier PTE and meta-frontier PTE, the range of the TGR scores for the sample countries ranged from 0.8610 (Indonesia) to 0.9227 (Japan). Compared to the meta-frontier PTE, the relatively small range of TGRs suggests that the distances between the country-frontiers and meta-frontier were similar among the sample countries. For example, the average TGR for Australian banks of 0.9091 indicates that Australian banks operating on the frontier can improve and move towards the meta-frontier by reducing inputs by 9.09%.

Table 7. Group-frontier PTE, Meta-frontier PTE, and TGRs for Sample Countries (2005 to 2014).

Countries	Group PTE		Meta PTE		TGR	
	Mean	SD	Mean	SD	Mean	SD
Australia (n = 119)	0.9982	0.0154	0.9039	0.0791	0.9091	0.0828
China (n = 627)	0.9232	0.0524	0.8245	0.1175	0.8930	0.1060
Hong Kong (n = 156)	0.9843	0.0203	0.8958	0.0665	0.9099	0.0630
Indonesia (n = 389)	0.8529	0.1418	0.7312	0.1564	0.8610	0.1292
Japan (n = 941)	0.9588	0.0269	0.8847	0.07	0.9227	0.0688
New Zealand (n = 60)	0.9636	0.0272	0.8603	0.1443	0.8897	0.1266
Singapore (n = 54)	1	0	0.877	0.102	0.8770	0.1020
Thailand (n = 159)	0.9785	0.0284	0.8737	0.066	0.8929	0.0627

Notes: group PTE = group-frontier pure technology efficiency; meta PTE = meta-frontier pure technical efficiency; TGR = technology gap ratio. Source: Author’s calculations.

5.3. Bootstrap Truncated Regression Results

5.3.1. Impact of Bank Regulation, Supervision, and Ownership on Bank Efficiency

To examine whether bank regulation, supervision, and state ownership in banks have significant influences on bank performance, the second-stage bootstrap regression model (Simar and Wilson 2007) was employed in this study. The pairwise correlated coefficients of the independent variables indicated no major issues of multicollinearity in the regression (see Appendix A Table A2). Additionally, robust standard errors were used in all the regression models to address potential heteroskedasticity problems. Year dummy and country dummy variables were included in the regression model to capture the impact of time and other unspecified country-specific characteristics.

Table 8 shows the regression results of the relationship between regulation, supervision and bank efficiencies (that is, PTE—pure technical efficiency, SE—scale efficiency, and TGR—technology gap ratio) using the full sample data of 2186 bank-year observations. Overall, the regression results show that regulation and supervision policies are positively related to pure technical efficiency and technology gap ratio of banks in the Asia-Pacific region. Following the first pillar of the Basel Accord, the capital requirement had a positive relationship with PTE and TGR at a 1% significance level. Consistent with previous empirical studies (Lozano-Vivas and Pasiouras 2010; Barth et al. 2013; Luo et al. 2016), stricter capital requirements can reduce the incentive to engage in risky behavior, and therefore improve the bank performance. The positive relationship between capital regulation and scale efficiency was insignificant.

Table 8. Bootstrap truncated regression Results: Full sample data.

Variables	Model 4			Model 1		
	Pure Technical Efficiency	Scale Efficiency	Technology Gap Ratio	Pure Technical Efficiency	Scale Efficiency	Technology Gap Ratio
Regulation and Supervision						
CAPITAL	0.0413 *** (3.3049)	−0.0008 (0.1182)	0.0414 *** (2.7251)	0.0143 (1.4627)	−0.0051 (0.6653)	0.0024 (0.2161)
SPPOWER	0.0112 ** (2.2398)	0.0052 (1.2695)	0.0304 *** (4.3678)	0.0162 *** (3.6520)	−0.0027 (0.7370)	0.0346 *** (5.8246)
MKDSPL	0.0934 ** (2.0006)	0.0802 ** (2.1102)	0.2591 *** (3.6960)	0.0797 ** (2.0011)	0.0811 ** (2.3647)	0.1682 *** (2.7786)
ACRS	0.0252 ** (2.4088)	−0.0035 (0.4291)	0.0536 *** (3.2889)	0.0180 ** (2.0262)	−0.0011 (0.1505)	0.0281 ** (1.9672)
DEP_INS	−0.0180 (0.7791)	0.0119 (0.6636)	−0.0015 (0.0447)	0.0003 (0.0132)	0.0502 *** (3.2407)	−0.0039 (0.1462)

Table 8. Cont.

Variables	Model 4			Model 1		
	Pure Technical Efficiency	Scale Efficiency	Technology Gap Ratio	Pure Technical Efficiency	Scale Efficiency	Technology Gap Ratio
Bank Ownership						
STATE	−0.0146 (1.2922)	0.0101 (1.1599)	−0.0209 (1.3806)	−0.0078 (0.8073)	0.0024 (0.2894)	−0.0130 (1.0847)
Bank-specific						
BANKSIZE	0.0387 *** (13.1486)	−0.0307 *** (18.0733)	0.0496 *** (8.6720)	0.0353 *** (16.1771)	−0.026 *** (16.1730)	0.0397 *** (11.4585)
EQTA	0.5016 *** (7.7435)	0.1470 *** (3.2061)	0.5327 *** (5.9613)	0.4708 *** (8.8300)	0.1332 *** (2.7354)	0.4169 *** (6.4345)
LIQTA	−0.1147 *** (2.8748)	0.0359 (1.3852)	−0.1367 ** (2.3743)	−0.0752 ** (2.1534)	0.0044 (0.1807)	−0.0435 (1.0027)
OBSTA				−0.0261 (1.2194)	0.0113 * (1.7808)	−0.0161 (1.1607)
LLPTL				−0.1660 (0.4644)	−1.568 *** (4.4302)	−0.4978 (1.2061)
Country-specific						
GDP_growth	0.0028 (1.2052)	−0.0007 (0.4408)	0.0034 (0.9910)	0.0053 *** (3.0187)	0.0009 (0.6334)	0.0110 *** (4.3530)
INF	0.0021 (1.5009)	0.0040 *** (3.1245)	−0.0074 *** (3.2805)	0.0024** (2.0932)	0.0040 *** (3.3899)	−0.0059 *** (3.5733)
HHI	0.1704 (1.3020)	0.1153 (1.3683)	−0.0530 (0.3083)	0.0569 (0.5487)	−0.0385 (0.6604)	−0.1445 (1.1137)
PrCrGDP	−0.0014 *** (2.9624)	−0.0000 (0.1594)	−0.0016 ** (2.4151)	−0.0000 (0.0459)	−0.0006 ** (2.3849)	0.0008 * (1.8283)
INST_ENV	−0.0403 (1.3761)	−0.0369 (1.5343)	−0.0264 (0.6527)	−0.066 *** (2.7279)	−0.0249 (1.1007)	−0.0481 (1.4502)
Constant	(2.4733) −0.3658	(0.7818) 0.8555 ***	(3.7280) −1.7831 ***	(2.5700) −0.4160	(1.5091) 0.8127 ***	(2.3282) −1.2376 **
Sigma	(0.9459) 0.1028 ***	(2.7512) 0.0996 ***	(2.9241) 0.1154 ***	(1.2686) 0.0925 ***	(2.9727) 0.0892 ***	(2.3473) 0.1055 ***
Country Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table reports the coefficients of regulation and supervision variables, state ownership, and other control variables in the Simar and Wilson (2007) bootstrap truncated regression models. Z-statistics are shown in the parentheses. See Appendix A Table A1 for definitions and information about the independent variables. *, **, *** indicates 10%, 5% and 1% levels of significance, respectively. Source: Author’s calculations.

Similar to the capital requirement, the second pillar of the Basel Accord (that is, the official supervision power), is positively related to both PTE and TGR at 5% significance level. Under the “official supervision approach,” greater official supervision power is believed to increase credit flow to firms which are well-connected with banks (Levine 2004) and enhances bank performance. Furthermore, a powerful official supervision regime can improve bank efficiency through increased competition in the banking industry (Barth et al. 2008). Empirically, our result is consistent with Pasiouras (2008a) and Luo et al.’s (2016) findings on global banking industries. Hirtle et al. (2016) found similar results in the US bank-holding companies. Official supervisory power is not significantly related to banks’ scale efficiency.

The significantly positive coefficients of market discipline on PTE, SE, and TGR estimates support the “private monitoring approach” hypothesis, in which regulation and supervision policies promoting private monitoring in banks can induce better performance. By requiring banks to disclose adequate

information to the public, market discipline can encourage private sectors to monitor banks with lower information and transaction costs (Barth et al. 2008). Table 8 shows that market discipline is the only regulation and supervision variable which is significantly (at a 5% significance level) related to the scale efficiency of banks in the Asia-Pacific region.

Banks with more activity restrictions tend to have higher performance, in both pure technical efficiency and technology gap ratios. These findings are similar to Barth et al.'s (2004) discussion that restricting banks engagement in security underwriting, insurance underwriting, and real estate investments would limit the conflicts of interest between stakeholders. Furthermore, narrowing the range of activities can reduce risky behaviours caused by moral hazards (Boyd et al. 1998) and positively affect bank performance. There is no evidence to suggest a significant relationship between activity restrictions and scale efficiency.

The existence of a deposit insurance scheme in each country has no significant relationship with bank performance according to our results. Additionally, state ownership is not significantly related to bank performance in the Asia-Pacific region. Bank-specific characteristics exhibit significant relationships with bank efficiencies. For example, bank size is positively related to technical efficiency and technical gap ratio, indicating that larger banks have better management and technology in their production processes. However, bank scale efficiency tends to be lower for larger banks, possibly due to the fact that most banks in the Asia-Pacific region expanded too quickly and operated at decreasing returns to scale during the 10-year sample period.

In addition, banks with higher capital ratios performed better in all three efficiency estimates. When banks hold more capital, managers tend to be more risk-averse in terms of operation, and therefore these banks would exhibit better performance. Our results are consistent with most of the previous studies in bank performance (see Demirgüç-Kunt and Huizinga 1999; Goddard et al. 2004; Sufian and Habibullah 2010; Fiordelisi et al. 2011; and Pessarossi and Weill 2015).

The level of liquid assets (LIQTA) in banks has a negative relationship with technical efficiency and technical gap ratio, but no significant correlation with scale efficiency. One possible reason for a higher level of liquid assets could be that banks would raise more liquid assets to reduce risks during times of uncertainty and unfavourable industry conditions (Radić et al. 2012). Thus, banks tend to have a lower performance during those times. Moreover, liquid assets are believed to be less profitable than illiquid assets and reduce investment opportunities for banks managers. The negative relationship between liquid ratio and technical gap ratio implies that holding more liquid assets would widen the distance from the group frontiers to the meta-frontier in banking industry.

The coefficients of GDP growth are not significantly related to bank performance, while a higher inflation rate has a positive relationship with scale efficiency and a negative impact on technology gap ratio. The concentration (HHI) of the banking industry appears unrelated to bank performance in the Asia-Pacific region. Furthermore, the negative coefficients of PrCrGDP indicate a negative relationship between private credit from banks to GDP and bank performance, suggesting that financial markets with more lending to private credit have relatively lower bank performance. The overall institutional environment of banks exhibits no significant relationship with bank performance in the Asia-Pacific region.

5.3.2. Regulation, Supervision, and Bank Size

After categorising banks into three size groups—small, medium and large, based on banks' total assets, we conducted further analysis to examine if the impacts of regulation, supervision, and state ownership on bank efficiency would be different in different sized groups. Table 9 shows the regression results for each bank groups, using meta-frontier efficiency from Model 4 as the dependent variable. Our findings in Table 9 suggest that stricter regulation and supervision policies are mostly positively related to small-sized banks, but not to medium or large-sized banks.

The first three columns in Table 9 compare the impact of regulation, supervision, and state ownership on pure technical efficiency for three sized bank groups. Tighter capital regulation and

market discipline are significantly related to higher pure technical efficiency of small banks at a 1% significant level. At the 10% significance level, activity restriction is positively associated with the pure technical efficiency of small banks. While official supervisory power has no significant relationship with the technical efficiency of small and medium banks, it is positively related to large bank efficiency at a 5% significance level. None of the regulatory and supervisory policies are significantly related to the pure technical efficiency of medium-sized banks.

Columns 4 to 6 in Table 9 summarise the regression results on scale efficiency for different-sized banks. The official supervision power and market discipline are significantly related to the scale efficiency of small banks. Additionally, market discipline is also positively related to large-sized banks' scale efficiency. There is no significant impact of bank regulation and supervision on medium-sized banks. Compared to the pure technical efficiency, scale efficiencies of banks are less affected by regulation and supervision. The deposit insurance scheme is positively related to the small-sized banks' scale efficiency at the 10% significance level.

The relationships of regulation and supervision and bank technology gap ratio are shown in columns 7 to 9 in Table 9. All four regulatory and supervisory indicators are positively related to the technology gap ratio of small banks. For large banks, official supervisory power is positively associated with the technology gap ratio. The medium-sized banks' technology gap ratios are not affected by any of the regulation and supervision indicators.

Table 9. Bootstrap truncated regression results: Different-sized bank groups.

Variables	(Columns 1–3) Pure Technical Efficiency			(Columns 4–6) Scale Efficiency			(Columns 7–9) Technology Gap Ratio		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Regulation and Supervision									
CAPITAL	0.0757 *** (2.9635)	0.0171 (1.0773)	0.0045 (0.4986)	0.0202 (1.1485)	−0.0067 (0.3498)	−0.0185 (1.1844)	0.0839 ** (2.4592)	0.0172 (0.8045)	−0.0052 (0.3606)
SPPOWER	0.0100 (0.9637)	0.0011 (0.1682)	0.0081 ** (2.1796)	0.0310 *** (2.9870)	−0.0019 (0.2548)	−0.0014 (0.3157)	0.0301 ** (2.0693)	0.0115 (1.4927)	0.0186 *** (3.9669)
MKDSPL	0.2654 *** (2.6430)	−0.0521 (0.7393)	−0.0582 (1.3764)	0.1474 * (1.8145)	0.0507 (0.6432)	0.1194** (2.0539)	0.5115 *** (3.0413)	−0.0102 (0.1138)	0.0492 (1.0305)
ACRS	0.0398 * (1.8009)	−0.0010 (0.0700)	0.0053 (0.6782)	0.0229 (1.3651)	−0.0230 (1.3770)	0.0039 (0.3400)	0.0711 * (1.9474)	0.0124 (0.6400)	0.0150 (1.4497)
DEP_INS	−0.0671 (1.2391)	−0.0296 (0.8829)	−0.0042 (0.2506)	0.0676* (1.6483)	−0.0079 (0.2217)	−0.0093 (0.4429)	−0.0989 (1.2326)	−0.0052 (0.1297)	0.0157 (0.7598)
Ownership									
STATE	0.0194 (0.6326)	−0.0185 (1.1080)	0.0106 (1.3256)	0.0259 (0.9567)	0.0139 (0.6755)	−0.0105 (1.3329)	0.0077 (0.1578)	0.0011 (0.0628)	0.0073 (0.9588)
Bank-specific									
EQTA	0.3548 *** (4.3773)	0.0093 (0.0592)	0.1332 (0.6794)	0.2146 *** (3.7184)	0.1388 (1.2648)	−0.5144 ** (2.3111)	0.3188 *** (2.9380)	−0.0429 (0.2479)	−0.2266 (1.1389)
LIQTA	−0.0703 (0.9504)	−0.1182 ** (2.0130)	−0.1880 *** (3.6610)	0.0058 (0.1367)	0.0468 (0.8438)	−0.0002 (0.0052)	−0.1221 (1.1268)	−0.2056 *** (2.8275)	−0.1114 ** (2.4968)
Country-specific									
GDP_growth	0.0117 ** (2.2114)	−0.0041 (1.4506)	−0.0006 (0.3212)	−0.0060 * (1.6692)	0.0004 (0.1465)	0.0021 (1.1888)	0.0234 *** (2.8115)	−0.0068 ** (2.1655)	−0.0031 (1.4766)
INF	0.0019 (0.6360)	0.0032 * (1.6664)	−0.0005 (0.3732)	0.0059 ** (2.2244)	0.0070 *** (3.0186)	0.0038 ** (2.3868)	−0.0071 (1.4969)	−0.0100 *** (4.1489)	−0.0030 ** (2.2244)
HHI	0.0844 (0.2927)	0.2166 (1.4563)	0.0134 (0.1662)	0.3355 (1.3775)	0.2716 (1.4077)	−0.1003 (1.2404)	0.0661 (0.1283)	−0.2207 (1.4719)	−0.2000 *** (2.7198)
PrCrGDP	−0.0005 (0.4741)	−0.0013** (2.4554)	−0.0007* (1.7261)	0.0002 (0.2486)	−0.0005 (0.9370)	−0.0009** (2.4464)	−0.0004 (0.2328)	−0.0015** (2.3008)	−0.0004 (1.0400)
INST_ENV	−0.1690 *** (2.7521)	−0.0534 (1.1384)	0.0559 * (1.9522)	0.0351 (0.6148)	−0.0643 (1.3926)	−0.0944 *** (3.4470)	−0.2765 *** (3.2453)	0.0462 (0.8689)	0.0597 ** (2.3521)
Constant	−0.7725 (0.9831)	1.5390 *** (2.9823)	1.2107 *** (4.0531)	−0.7807 (1.1678)	0.7517 (1.2258)	0.4405 (1.0432)	−2.3958* (1.7966)	1.1413 (1.6180)	0.4574 (1.2343)
sigma	0.1270 *** (19.2102)	0.0885 *** (16.7169)	0.0558 *** (11.2685)	0.1095 *** (25.7747)	0.0995 *** (30.6333)	0.0699 *** (25.7247)	0.1480 *** (12.9352)	0.0868 *** (11.7518)	0.0501 *** (17.0131)
Country Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table reports the bootstrap truncated regression results in different-sized bank groups. Z-statistics are shown in parentheses. The pure technical efficiency, scale efficiency, and technology gap ratio scores are estimated in Model 4. See Table A1 for definitions and information on the independent variables. *, **, *** indicate 10%, 5% and 1% levels of significance, respectively. Source: Author's calculations.

5.4. Robustness Check: Tobit Regression and Fractional Logit Regression

This study employs the [Simar and Wilson \(2007\)](#) bootstrap truncated regression model to examine the relationship between bank regulation, supervision, ownership and bank efficiency. In previous studies, different types of regression models were used in the second stage after obtaining the DEA efficiency estimates. For example, most of the previous studies ([Pasiouras 2008a](#); [Sufian 2009](#); [Gardener et al. 2011](#); [Ab-Rahim et al. 2012](#); [Huang and Fu 2013](#)) used the Tobit regression to identify determinants of bank efficiency. Alternatively, [Ramalho et al. \(2010\)](#) suggested that fractional logit regression is the most natural way for second-stage regression.

To check the robustness of our regression results, we applied both fractional logit regression and Tobit regression in the second stage, to examine the relationship between regulation, supervision, ownership and bank performance (see [Table 10](#)). In both regressions, we used technical efficiency, scale efficiency, and technology gap ratio in Model 4 as the dependent variables, with the same independent variables as in the previous analysis.

Columns 1 to 3 in [Table 10](#) show the results of fractional logit regression, which are similar to the results in [Table 8](#). Regulation and supervision are positively related to bank pure technical efficiency and technology gap ratios. Additionally, market discipline is positively associated with bank scale efficiency in the Asia-Pacific region. However, we observe that the coefficient estimates in the fractional logit regression are larger than those in the truncated regression, and there are some variations in the Z-value compared to bootstrap truncated regression results.

Columns 4 to 6 in [Table 10](#) display the Tobit regression results of bank efficiency. Even though the coefficients of variables have the same signs, we observe that supervision power and market discipline are not significantly related to pure technical efficiency. All four regulation and supervision indices exhibited positive relationships with the technology gap ratio of banks. Similar to the discussion in [Section 5.3](#), deposit insurance schemes and state ownership were not significantly related to bank performance in both fractional logit and Tobit regression models.

Table 10. Robustness test results: Fractional logit regression and tobit regression.

Variables	Fractional Logit Regression			Tobit Regression		
	Pure Technical Efficiency	Scale Efficiency	Technology Gap Ratio	Pure Technical Efficiency	Scale Efficiency	Technology Gap Ratio
Regulation and Supervision						
CAPITAL	0.2069 *** (3.6605)	−0.0081 (0.2649)	0.1789 *** (2.8087)	0.0201 *** (2.8396)	0.0010 (0.1533)	0.0164 ** (2.5060)
SPPOWER	0.0506 * (1.7768)	0.0269 * (1.7727)	0.1205 *** (3.8051)	0.0026 (1.0131)	0.0043 (1.1047)	0.0079 *** (3.2451)
MKDSPL	0.4634 * (1.9161)	0.4098 ** (2.3118)	1.0504 *** (3.6772)	0.0313 (1.2163)	0.0680 * (1.8896)	0.0926 *** (3.3342)
ACRS	0.1274 ** (2.3162)	−0.0152 (0.4514)	0.2119 *** (3.1935)	0.0132 ** (2.3242)	−0.0032 (0.4276)	0.0153 *** (2.5911)
DEP_INS	−0.0607 (0.6188)	0.0562 (0.7962)	−0.0130 (0.1182)	0.0049 (0.4296)	0.0116 (0.7011)	−0.0011 (0.0902)
Ownership STATE	−0.0719 (0.8184)	0.0565 (0.7775)	−0.0997 (1.1219)	−0.0103 (1.3123)	0.0073 (0.9210)	−0.0098 (1.2725)
Bank-specific						
BANKSIZE	0.1973 *** (10.6387)	−0.146 *** (9.7058)	0.2134 *** (8.7663)	0.0221 *** (15.0755)	−0.028 *** (18.8324)	0.0179 *** (11.9368)
EQTA	2.5618 *** (5.8482)	0.8073 ** (2.4078)	2.2581 *** (4.6255)	0.2827 *** (7.5429)	0.0929 ** (2.4482)	0.1958 *** (5.5274)
LIQTA	−0.6041 ** (2.2406)	0.1807 (0.9800)	−0.6323 ** (2.0175)	−0.082 *** (2.8372)	0.0269 (1.1919)	−0.077 *** (2.8936)

Table 10. Cont.

Variables	Fractional Logit Regression			Tobit Regression		
	Pure Technical Efficiency	Scale Efficiency	Technology Gap Ratio	Pure Technical Efficiency	Scale Efficiency	Technology Gap Ratio
Country-specific						
GDP_growth	0.0168 (1.3993)	−0.0036 (0.5275)	0.0172 (1.2214)	0.0033 *** (2.5957)	−0.0002 (0.1132)	0.0051 *** (3.9388)
INF	0.0102 (1.4189)	0.0200 *** (3.7307)	−0.031 *** (3.5093)	0.0019 * (1.8685)	0.0032 *** (2.8496)	−0.004 *** (4.3943)
HHI	0.7608 (1.2715)	0.5872* (1.6500)	−0.0714 (0.1111)	0.0670 (1.4434)	0.0585 (1.0167)	0.0087 (0.2193)
PrCrGDP	−0.0075 ** (2.4916)	0.0000 (0.0279)	−0.0071** (2.0615)	−0.001 *** (3.2615)	−0.0001 (0.4575)	−0.0006 ** (2.5366)
institutional_env	−0.1883 (1.3395)	−0.2061 ** (2.0546)	−0.1553 (0.8973)	−0.0441 ** (2.1493)	−0.0287 (1.2977)	−0.0086 (0.4657)
Constant	−4.4315 ** (2.1735)	1.4683 (1.0551)	−9.105 *** (3.6945)	0.3335 * (1.6557)	0.8862 *** (3.0197)	−0.0705 (0.3283)
Sigma				0.0810 *** (39.7257)	0.0958 *** (56.2804)	0.0755 *** (34.1237)
Country Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table reports the relationship between bank regulation and supervision on efficiencies of banks using fractional logit regression (columns 1–3) and ordinary least square regression (columns 4–6). Z-values are shown in the parenthesis. PTE, SE, and TGR estimates from Model 4 are used as the dependent variables. Statistically significance at 10% level. *, **, *** indicates 10%, 5% and 1% levels of significance, respectively. Source: Author's calculations.

6. Conclusions

This study examined the impacts of off-balance sheet activities on bank efficiency measurement, and investigated the relationship between regulation, supervision, state ownership and bank efficiency. Our results showed that omitting off-balance sheet activities while estimating bank efficiency using bootstrap DEA approach would significantly underestimate the pure technical efficiency and overall technical efficiency, while overestimating the scale efficiency of banks. Furthermore, we identified the positive relationship between regulation, supervision, and bank efficiency, especially in small-sized banks. However, no significant relationship between state ownership with bank performance was found in this study.

Our findings have imperative policy implications. Firstly, our results have highlighted the impact of including non-traditional bank activities when measuring bank efficiency. Precise information relating to bank performance is essential for policy-making decisions, such as capital requirements and information disclosure. Correctly estimated efficiency could reveal the banks' intrinsic value and potential investment return in the future. Such information could further assist investors' and bank managers' decision making. Secondly, regulatory and supervisory authorities could impose customized regulatory and supervisory policies on different sized banks. While smaller banks benefit more from stricter policies, regulatory authorities could relax the requirements for medium and large-sized banks to exploit operational efficiency. Finally, since state ownership is found to be insignificantly related to bank performance, it could be an appropriate tool for governments to intervene in the banking industry during financial turmoil to maintain the intermediary function of banks.

There exist several limitations of the current study. First, we used the nonparametric DEA approach to estimate bank efficiency. Compared to the parametric approaches, the DEA method assumes the random error to be zero, which could affect the precision of efficiency estimation. Second, due to the data availability of bank regulation and supervision, we used the 2007 and 2011 World Bank Regulatory and Supervisory Survey to cover the 10-year sample period. Therefore, the timeliness and frequency of data could have potentially limited the validity of our results. Last, our sample covered eight countries in the Asia-Pacific region based on data availability. There were five developed

countries and three developing countries. Even though these countries can capture the diversity and common characteristics of the Asia-Pacific banking industries, questions remain whether our results can be applied to all banking industries in the region.

In future studies, we recommend different approaches, such as the stochastic frontier analysis approach, to estimate bank efficiency to avoid potential biases arising from the zero-error assumption of the DEA approach. Future researchers can collect more detailed bank-specific and country-specific data from more sample countries. Using these detailed data, future researchers can explore the timely changes in regulatory policies and their impacts on bank performance, and provide evidence which can be used to benefit the stakeholders in all the banks in the Asia-Pacific region.

Author Contributions: Z.Y. contributed to the research design and data analysis, writing, and formal analysis of the research. C.G. and Z.L. supervised the research. Z.Y. and C.G. helped with the modifying of the manuscript and final editorial clarifications and corrections. All authors contributed to the writing, reviewing, and correction of this manuscript.

Funding: This research received no external funding.

Acknowledgments: Baiding Hu has provided valuable insights into the methodology and statistical analysis of the the study.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Definition and data source of variables used in the regression models.

Variables	Definition	Data Source
Regulation and supervision		
CAP_k	Initial and overall capital requirements for banks in country k	World Bank (2007, 2011)
$SPPOER_k$	Extent of official supervision power to oversee, monitor, and discipline managers, directors, and auditors of banks in country k	World Bank (2007, 2011)
$MKDSPL_k$	Information disclosure to regulators, shareholders, auditors, and public and whether any credit ratings are required for banks in country k	World Bank (2007, 2011)
$ACRS_k$	Bank activity restrictions in real estate investment, insurance underwriting and selling, brokering and dealing securities, and all aspects of mutual fund industries in country k	World Bank (2007, 2011)
Ownership Variable		
$Ownership_{k,i}$	State ownership of the bank, equals 1 when bank is state-owned, otherwise 0.	Calculated based on information from BvD Bankscope
Bank-specific Variables		
$Banksiz_{i,k}$	Bank size, calculated as logarithm of the total assets of the bank.	BvD Bankscope
$EQTA_{i,k}$	Bank capitalisation, calculated as total equity divided by total assets.	BvD Bankscope
$LIQTA_{i,k}$	Bank liquidity risk, calculated by liquid assets divided by total assets.	BvD Bankscope
$OBS_{i,k}$	Bank operating risk, calculated as off-balance sheet items divided by total assets.	BvD Bankscope
$LLPTL_{i,k}$	Bank credit risk, calculated as loan loss provisions over the total loans.	BvD Bankscope

Table A1. Cont.

Variables	Definition	Data Source
Country-specific Variables		
GDP_growth_k	Real GDP growth in the country.	Global Financial Development Database
INF_k	Annual rate of the implicit GDP deflator.	Global Financial Development Database
HHI_k	Herfindall Hirschman Index, calculated as sum of square for deposit shares for each bank in all banks in the country.	Calculated by author using data from BvD Bankscope
$PrCrGDP_k$	Bank claims to the private sector to GDP.	Global Financial Development Database
INS_ENV_k	Institutional governance index, consists of voice and accountability, political stability and absence of violence or terrorism, government effectiveness, regulatory quality, the rule of law, control of corruption.	Calculated using data from World Governance Indicators database

Table A2. Pairwise correlation between independent variables in the regression.

	CAPITAL	SPPOWER	MKDSPL	ACRS	DEP_INS	STATE	BANKSIZE	OBS	EQTA	LLPTL	LIQTA	GDP_growth	INF	HHI	PrCrGDP	INST_ENV
CAPITAL	1															
SPPOWER	0.045 *	1														
MKDSPL	0.159 *	-0.605 *	1													
ACRS	-0.115 *	0.276 *	-0.195 *	1												
DEP_INS	-0.028	0.443 *	-0.6268 *	-0.4598 *	1											
STATE	0.0327	0.063 *	0.0530 *	0.1850 *	-0.1857 *	1										
BANKSIZE	0.0798 *	-0.181 *	0.2173 *	-0.0841 *	-0.0456 *	0.1107 *	1									
OBS	0.0323	-0.008	0.0997 *	-0.0077	-0.1063 *	0.0313	-0.0343	1								
EQTA	0.0531 *	0.005	-0.005	-0.0643 *	-0.0728 *	-0.0166	-0.5176 *	0.1393 *	1							
LLPTL	-0.0767 *	0.128 *	-0.0735 *	0.2122 *	-0.0966 *	0.1313 *	-0.2009 *	0.1486 *	0.1034 *	1						
LIQTA	0.0918 *	-0.1684 *	0.2815 *	0.0308	-0.3004 *	0.1378 *	-0.2498 *	0.1665 *	0.2936 *	0.2042 *	1					
GDP_growth	0.0105	-0.123 *	0.4185 *	0.3590 *	-0.6253 *	0.2624 *	-0.1484 *	0.1336 *	0.1739 *	0.1930 *	0.4659 *	1				
INF	-0.048 *	0.150 *	-0.138 *	0.3437 *	-0.178 *	0.2353 *	-0.3816 *	0.1099 *	0.2590 *	0.3138 *	0.3962 *	0.4841 *	1			
HHI	-0.146 *	-0.361 *	0.3589 *	-0.492 *	-0.0829 *	-0.0412	-0.0023	0.1325 *	0.1539 *	-0.085 *	0.2369 *	0.1600 *	0.0737 *	1		
PrCrGDP	0.1333 *	-0.696 *	0.6954 *	-0.367 *	-0.275 *	-0.143 *	0.4023 *	0.0626 *	-0.126 *	-0.255 *	0.0214	-0.0542 *	-0.513 *	0.3332 *	1	
INST_ENV	-0.120 *	-0.180 *	-0.08 *	-0.641 *	0.5179 *	-0.3513 *	0.2866 *	-0.1868 *	-0.2115 *	-0.379 *	-0.398 *	-0.6621 *	-0.62 *	0.302 *	0.3866 *	1

Notes: See Table A1 for definitions for variables. * indicates 5% level of significance. Source: Author's calculation.

References

- Ab-Rahim, Rossazana, Nor Ghani Md-Nor, Shamsubarida Ramlee, and Nur Zaimah Ubaidillah. 2012. Determinants of cost efficiency in Malaysian banking. *International Journal of Business and Society* 13: 355–74.
- Altunbas, Yener, Ming-Hau Liu, Philip Molyneux, and Rama Seth. 2000. Efficiency and risk in Japanese banking. *Journal of Banking & Finance* 24: 1605–28. [\[CrossRef\]](#)
- Barry, Thierno, Santos Jose Dacanay III, Laetitia Lepetit, and Amine Tarazi. 2008. Ownership Structure and Bank Efficiency in the Asia Pacific Region. SSRN. [\[CrossRef\]](#)
- Barth, James R., Gerard Caprio Jr., and Ross Levine. 2001. Banking systems around the globe: Do regulation and ownership affect performance and stability? In *Prudential Supervision: What Works and What Doesn't*. Chicago: University of Chicago Press, pp. 31–96.
- Barth, James R., Gerard Caprio Jr., and Ross Levine. 2004. Bank regulation and supervision: What works best? *Journal of Financial Intermediation* 13: 205–48. [\[CrossRef\]](#)
- Barth, James R., Gerard Caprio Jr., and Ross Levine. 2007. *The Microeconomic Effects of Different Approaches to Bank Supervision. The Politics of Financial Development*. Palo Alto: Stanford University Press.
- Barth, James R., Gerard Caprio Jr., and Ross Levine. 2008. *Rethinking Bank Regulation: Till Angels Govern*. Cambridge: Cambridge University Press.
- Barth, James R., Gerard Caprio Jr., and Ross Levine. 2012. *The Evolution and Impact of Bank Regulations*. Washington: The World Bank.
- Barth, James R., Chen Lin, Yue Ma, Jesús Seade, and Frank M. Song. 2013. Do bank regulation, supervision and monitoring enhance or impede bank efficiency? *Journal of Banking & Finance* 37: 2879–92. [\[CrossRef\]](#)
- Berger, Allen N., George R. G. Clarke, Robert Cull, Leora Klapper, and Gregory F. Udell. 2005. Corporate governance and bank performance: A joint analysis of the static, selection, and dynamic effects of domestic, foreign, and state ownership. *Journal of Banking & Finance* 29: 2179–221. [\[CrossRef\]](#)
- Berger, Allen N., Iftekhar Hasan, and Mingming Zhou. 2009. Bank ownership and efficiency in China: What will happen in the world's largest nation? *Journal of Banking & Finance* 33: 113–30.
- Bonin, John P., Iftekhar Hasan, and Paul Wachtel. 2005. Bank performance, efficiency and ownership in transition countries. *Journal of Banking & Finance* 29: 31–53. [\[CrossRef\]](#)
- Boyd, John H., Chun Chang, and Bruce D. Smith. 1998. Moral Hazard under Commercial and Universal Banking. *Journal of Money, Credit and Banking* 30: 426–68. [\[CrossRef\]](#)
- Brunnermeier, Markus K. 2009. Financial crisis: Mechanism, prevention and management. *Macroeconomic Stability and Financial Regulation: Key Issue for the G 20*: 91–104.
- Capannelli, Giovanni, and Carlo Filippini. 2010. Economic Integration in East Asia and Europe: Lessons from a Comparative Analysis. *The Singapore Economic Review* 55: 163–84. [\[CrossRef\]](#)
- Charnes, Abraham, William W. Cooper, Zhimin Huang, and Dee Bruce Sun. 1990. Polyhedral Cone-Ratio DEA Models with an illustrative application to large commercial banks. *Journal of Econometrics* 46: 73–91. [\[CrossRef\]](#)
- Chortareas, Georgios E., Claudia Girardone, and Alexia Ventouri. 2012. Bank supervision, regulation, and efficiency: Evidence from the European Union. *Journal of Financial Stability* 8: 292–302. [\[CrossRef\]](#)
- Chortareas, Georgios E., Claudia Girardone, and Alexia Ventouri. 2013. Financial freedom and bank efficiency: Evidence from the European Union. *Journal of Banking & Finance* 37: 1223–31.
- Cihak, Martin, and Asli Demirgüç-Kunt. 2013. *Rethinking the State's Role in Finance*. Washington: The World Bank.
- Clark, Jeffery Arthur, and Tom Siems. 2002. X-efficiency in banking: Looking beyond the balance sheet. *Journal of Money, Credit, and Banking* 34: 987–1013. [\[CrossRef\]](#)
- Coelli, Timothy J., Dodla Sai Prasada Rao, Christopher J. O'Donnell, and George Edward Battese. 2005. *An introduction to Efficiency and Productivity Analysis*. Berlin: Springer Science & Business Media.
- Cook, Wade D., and Larry M. Seiford. 2009. Data envelopment analysis (DEA)—Thirty years on. *European Journal of Operational Research* 192: 1–17. [\[CrossRef\]](#)
- Cornett, Marcia Millon, Lin Guo, Shahriar Khaksari, and Hassan Tehranian. 2010. The impact of state ownership on performance differences in privately-owned versus state-owned banks: An international comparison. *Journal of Financial Intermediation* 19: 74–94. [\[CrossRef\]](#)

- Demirgüç-Kunt, Ash, and Harry Huizinga. 1999. Determinants of commercial bank interest margins and profitability: some international evidence. *The World Bank Economic Review* 13: 379–408. [CrossRef]
- DeYoung, Robert, and Gökhan Torna. 2013. Nontraditional banking activities and bank failures during the financial crisis. *Journal of Financial Intermediation* 22: 397–421. [CrossRef]
- Dong, Yizhe, Robert Hamilton, and Mark Tippett. 2014. Cost efficiency of the Chinese banking sector: A comparison of stochastic frontier analysis and data envelopment analysis. *Economic Modelling* 36: 298–308. [CrossRef]
- Drake, Leigh. 2001. Efficiency and productivity change in UK banking. *Applied Financial Economics* 11: 557–71. [CrossRef]
- Drake, Leigh, and Maximilian J. B. Hall. 2003. Efficiency in Japanese banking: An empirical analysis. *Journal of Banking & Finance* 27: 891–917. [CrossRef]
- Engle, Robert, Fariborz Moshirian, Sidharth Sahgal, and Bohui Zhang. 2014. *Banks non-interest Income and Global Financial Stability*. CIFR Paper No. 015/2014. Rochester: SSRN. [CrossRef]
- Fallah-Fini, Saeideh, Konstantinos Triantis, Jesus M. de la Garza, and William L. Seaver. 2012. Measuring the efficiency of highway maintenance contracting strategies: A bootstrapped non-parametric meta-frontier approach. *European Journal of Operational Research* 219: 134–45. [CrossRef]
- Fethi, Meryem Duygun, and Fotios Pasiouras. 2010. Assessing bank efficiency and performance with operational research and artificial intelligence techniques: A survey. *European Journal of Operational Research* 204: 189–98. [CrossRef]
- Fiordelisi, Franco, David Marques-Ibanez, and Phil Molyneux. 2011. Efficiency and risk in European banking. *Journal of Banking & Finance* 35: 1315–26.
- Freixas, Xavier, and Jean-Charles Rochet. 2008. *Microeconomics of Banking*. Cambridge: MIT Press.
- Fu, Xiaoqing Maggie, Yongjia Rebecca Lin, and Philip Molyneux. 2014. Bank efficiency and shareholder value in Asia Pacific. *Journal of International Financial Markets, Institutions and Money* 33: 200–22. [CrossRef]
- Gardener, Edward, Philip Molyneux, and Hoai Nguyen-Linh. 2011. Determinants of efficiency in South East Asian banking. *The Service Industries Journal* 31: 2693–719. [CrossRef]
- Gerschenkron, Alexander. 1962. *Economic Backwardness in Historical Perspective: A book of Essays*. Cambridge: Belknap Press of Harvard University Press.
- Goddard, John, Philip Molyneux, and John OS Wilson. 2004. The profitability of European banks: A cross-sectional and dynamic panel analysis. *The Manchester School* 72: 363–81. [CrossRef]
- Hall, Maximilian J. B., Karligash A. Kenjegalieva, and Richard Simper. 2012. Environmental factors affecting Hong Kong banking: A post-Asian financial crisis efficiency analysis. *Global Finance Journal* 23: 184–201. [CrossRef]
- Hirtle, Beverly, Anna Kovner, and Matthew Plosser. 2016. *The Impact of Supervision on Bank Performance*. FRB of NY Staff Report No. 768. Rochester: SSRN.
- Hossain, Mahmud, Pankaj K. Jain, and Santanu Mitra. 2013. State ownership and bank equity in the Asia-Pacific region. *Pacific-Basin Finance Journal* 21: 914–31. [CrossRef]
- Huang, Mei-Ying, and Tsu-Tan Fu. 2013. An examination of the cost efficiency of banks in Taiwan and China using the metafrontier cost function. *Journal of Productivity Analysis* 40: 387–406. [CrossRef]
- International Monetary Fund. 2013. *Asia and Pacific: Shifting Risks, New Foundations for Growth*. Washington: Internaional Monetary Fund, Available online: <https://www.imf.org/en/Publications/REO/APAC/Issues/2017/03/09/Shifting-Risks-New-Foundations-for-Growth> (accessed on 3 September 2018).
- Kilinc, Mustafa, and Bilin Neyapti. 2012. Bank regulation and supervision and its welfare implications. *Economic Modelling* 29: 132–41. [CrossRef]
- Kim, Teakdong, Bonwoo Koo, and Minsoo Park. 2013. Role of financial regulation and innovation in the financial crisis. *Journal of Financial Stability* 9: 662–72. [CrossRef]
- Kroszner, Randall S. 1998. Rethinking bank regulation: A review of the historical evidence. *Journal of Applied Corporate Finance* 11: 48–58. [CrossRef]
- La Porta, Rafael, Florencio Lopez-de-Silanes, and Andrei Shleifer. 1999. Corporate ownership around the world. *The Journal of Finance* 54: 471–517. [CrossRef]
- La Porta, Rafael, Florencio Lopez-de-Silanes, and Andrei Shleifer. 2002. Government ownership of banks. *The Journal of Finance* 57: 265–301. [CrossRef]
- Levine, Ross. 2004. *The Microeconomic Effects of Different Approaches to Bank Supervision*. Working Paper No. 237. Stanford: Stanford Center for International Development.

- Lieu, Pang-Tien, Tsai-Lien Yeh, and Yung-Ho Chiu. 2005. Off-balance sheet activities and cost inefficiency in Taiwan's Banks. *The Service Industries Journal* 25: 925–44. [CrossRef]
- Lin, Xiaochi, and Yi Zhang. 2009. Bank ownership reform and bank performance in China. *Journal of Banking & Finance* 33: 20–29. [CrossRef]
- Lozano-Vivas, Ana, and Fotios Pasiouras. 2010. The impact of non-traditional activities on the estimation of bank efficiency: International evidence. *Journal of Banking & Finance* 34: 1436–49. [CrossRef]
- Lozano-Vivas, Ana, and Fotios Pasiouras. 2014. Bank Productivity Change and Off-Balance-Sheet Activities across Different Levels of Economic Development. *Journal of Financial Services Research* 46: 271–94. [CrossRef]
- Luo, Yun, Sailesh Tanna, and Glauco De Vita. 2016. Financial openness, risk and bank efficiency: Cross-country evidence. *Journal of Financial Stability* 24: 132–48. [CrossRef]
- Margono, Heru, Subhash C. Sharma, and Paul D. Melvin Ii. 2010. Cost efficiency, economies of scale, technological progress and productivity in Indonesian banks. *Journal of Asian Economics* 21: 53–65. [CrossRef]
- McKinsey Company. 2016. Weathering the Storm: Asia-Pac Banking Review 2016. Available online: <https://www.mckinsey.com/industries/financial-services/our-insights/weathering-the-storm-asia-pacific-banking-review-2016> (accessed on 20 August 2017).
- Mester, Loretta J. 1996. A study of bank efficiency taking into account risk-preferences. *Journal of Banking & Finance* 20: 1025–45.
- Micco, Alejandro, Ugo Panizza, and Monica Yanez. 2007. Bank ownership and performance. Does politics matter? *Journal of Banking & Finance* 31: 219–41.
- O'Donnell, Christopher J., D. S. Prasada Rao, and George E. Battese. 2008. Metafrontier frameworks for the study of firm-level efficiencies and technology ratios. *Empirical Economics* 34: 231–55. [CrossRef]
- Pasiouras, Fotios. 2008a. International evidence on the impact of regulations and supervision on banks' technical efficiency: An application of two-stage data envelopment analysis. *Review of Quantitative Finance and Accounting* 30: 187–223. [CrossRef]
- Pasiouras, Fotios. 2008b. Estimating the technical and scale efficiency of Greek commercial banks: The impact of credit risk, off-balance sheet activities, and international operations. *Research in International Business and Finance* 22: 301–18. [CrossRef]
- Pasiouras, Fotios, Sailesh Tanna, and Constantin Zopounidis. 2009. The impact of banking regulations on banks' cost and profit efficiency: Cross-country evidence. *International Review of Financial Analysis* 18: 294–302. [CrossRef]
- Perera, Shrimal, Michael Skully, and Jayasinghe Wickramanayake. 2007. Cost Efficiency in South Asian Banking: The Impact of Bank Size, State Ownership and Stock Exchange Listings. *International Review of Finance* 7: 35–60. [CrossRef]
- Pessarossi, Pierre, and Laurent Weill. 2015. Do capital requirements affect cost efficiency? Evidence from China. *Journal of Financial Stability* 19: 119–27. [CrossRef]
- Radić, Nemanja, Franco Fiordelisi, and Claudia Girardone. 2012. Efficiency and risk-taking in pre-crisis investment banks. *Journal of Financial Services Research* 41: 81–101. [CrossRef]
- Ramalho, Esmeralda A., Joaquim J. S. Ramalho, and Pedro D. Henriques. 2010. Fractional regression models for second stage DEA efficiency analyses. *Journal of Productivity Analysis* 34: 239–55. [CrossRef]
- Rogers, Kevin E. 1998. Nontraditional activities and the efficiency of US commercial banks. *Journal of Banking & Finance* 22: 467–82. [CrossRef]
- Rosenkranz, Peter, and Junkyu Lee. 2019. *Nonperforming Loans in Asia: Determinants and Macroeconomic Linkages*. Asian Development Bank Economics Working Paper Series, No. 574. Rochester: SSRN.
- Shaban, Mohamed, and Gregory A. James. 2018. The effects of ownership change on bank performance and risk exposure: Evidence from Indonesia. *Journal of Banking & Finance* 88: 483–97. [CrossRef]
- Shleifer, Andrei. 1998. State versus private ownership. *Journal of Economic Perspectives* 12: 133–50. [CrossRef]
- Shleifer, Andrei, and Robert W. Vishny. 1994. Politicians and firms. *The Quarterly Journal of Economics* 109: 995–1025. [CrossRef]
- Simar, Léopol, and Paul Wilson. 2000. Statistical Inference in Nonparametric Frontier Models: The State of the Art. *Journal of Productivity Analysis* 13: 49–78. [CrossRef]
- Simar, Léopold, and Paul W. Wilson. 2007. Estimation and inference in two-stage, semi-parametric models of production processes. *Journal of Econometrics* 136: 31–64. [CrossRef]

- Sufian, Fadzlan. 2009. Determinants of bank efficiency during unstable macroeconomic environment: Empirical evidence from Malaysia. *Research in International Business and Finance* 23: 54–77. [[CrossRef](#)]
- Sufian, Fadzlan, and Muzafar Shah Habibullah. 2010. Bank-specific, Industry-specific and Macroeconomic Determinants of Bank Efficiency: Empirical Evidence from the Thai Banking Sector. *Margin: The Journal of Applied Economic Research* 4: 427–61. [[CrossRef](#)]
- Sufian, Fadzlan, Junaina Muhamad, A. N. Bany-Ariffin, Mohamed Hisham Yahya, and Fakarudin Kamarudin. 2012. Assessing the effect of mergers and acquisitions on revenue efficiency: Evidence from Malaysian banking sector. *Vision: The Journal of Business Perspective* 16: 1–11. [[CrossRef](#)]
- Tan, Yong, and John Anchor. 2017. The impacts of risk-taking behaviour and competition on technical efficiency: Evidence from the Chinese banking industry. *Research in International Business and Finance* 41: 90–104. [[CrossRef](#)]
- Triki, Thouraya, Imen Kouki, Mouna Ben Dhaou, and Pietro Calice. 2017. Bank regulation and efficiency: What works for Africa? *Research in International Business and Finance* 39: 183–205. [[CrossRef](#)]
- Viverita, and Mohamed Ariff. 2011. Efficiency measurement and determinants of Indonesian bank efficiency. *Academy of Financial Services*, May 30.
- Wang, Ke, Wei Huang, Jie Wu, and Ying-Nan Liu. 2014. Efficiency measures of the Chinese commercial banking system using an additive two-stage DEA. *Omega* 44: 5–20. [[CrossRef](#)]
- World Bank. 2007. *Bank Regulation and Supervision*. Washington: World Bank.
- World Bank. 2011. *Bank Regulation and Supervision*. Washington: World Bank.



© 2019 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).