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Efficiency Gains from Removing Trade Barriers: Evidence from Asian Banking Industries

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Abstract

This paper employs two stage data envelopment analysis (DEA) to investigate the efficiency effects of removing trade barriers on banking performance for a sample of Asian developing economies over the period 1997–2006. First, the DEA is employed to estimate the efficiency scores of banks. After that, the estimated DEA scores are analysed by density analysis and regressed on indices of trade barriers (Dinh 2008) that represent how restrictive the national trade policies are in the selected banking industries. The empirical evidence shows that deregulation policies that reduce restrictions on foreign banks have enhanced bank efficiency, while the deregulation of domestic banks has not resulted in significant efficiency gains.

Key words

Data envelopment analysis, financial deregulation, banking services

JEL codes

D21, D24, G21

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1. Introduction

In any economy, the banking industry takes a central and pivotal role – it allocates resources by accepting deposits from businesses and individuals and lending funds to the ‘real’ sector (the part of the economy actually producing goods and providing services). Since the banks function as intermediaries between savers and borrowers by channelling credit into the best economic opportunities, it is not surprising that in recent time policy-makers especially in developing countries have been concerned about the efficiency of their banking industries.[1] In developing countries, the firms often struggle to obtain enough financial support from their relatively underdeveloped and inefficient financial systems, but this problem could be at least partly countered by the increased efficiency of the banks.

One of the most common and direct strategies to raise efficiency is by deregulation of banking industries, where presumably, such deregulation would increase competition among banks and thus encourage them to operate more efficiently or face their demise (Delis et al., 2011). The regulation and supervision activities by the government may be broken up into two different groups according to their purposes – whether they are prudential regulations or non-prudential restrictions. According to the concept of the prudential regulation from Acharya (2009), the aim of prudential regulations is to ensure the financial stability of the whole system, not only banks individually but also as part of the overall banking system.[2] Any other extra requirements or restrictions are considered to be non-prudential restrictions, such as the trade policy in banking industries. Dinh (2008) argues that trade barriers on banking industries are expected to protect the franchise value of the incumbent banks in the market by restricting the

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[1] Some country-specific research on the efficiency effect from the financial deregulation policies: Leightner and Lovell (1998) on Thailand banks, Halkos and Salamouris (2004) on Greek banks, Drake et al. (2006) on Hong Kong banks and Das and Ghosh (2009) on Indian banks.

[2] The most famous international standard for prudential regulations is from the Basel Accords, the current version being number III.

nature and scope of newcomers in the market, regardless of whether they are domestic or foreign.[3] Compared to the vast empirical literature on bank regulation and supervision, the empirical analysis of trade barriers is still in its infancy. The purpose of the present study is to provide cross-country evidence about the efficiency effect of removing trade barriers on banking industries.

As an attempt to investigate the impact on banking efficiency, the indices from Dinh (2008) are utilised, since they cover most possible restrictions affecting banking services. The indices originated from the concepts defined by the General Agreement on Trade in Services (GATS) of the WTO in modes of financial service supply – cross-border supply (Mode 1), consumption abroad (Mode 2), commercial presence (Mode 3) and presence of natural persons (Mode 4). For example, restrictions include setting a maximum percentage of the foreign equity ownership of domestic banks or restrictions on the loan and deposit interest rates charged by banks (Dinh, 2008). Particularly, the trade barriers are classified as two types: (1) the deregulation of the domestic banking industry to allow for foreign banks to carry out business more freely; (2) the deregulation of domestic banks to allow these banks to carry out business more freely.[4] For presentation purposes, the overall index is demonstrated in Figure 1 as the sum of the index for foreign banks (upper bar) and the index for domestic banks (lower bar). The higher value of the Dinh indices indicates a higher presence of trade barriers in the market, so the change of the indices also indicates policy changes. For example, the value of the trade

[3] For example, the five-year transitional arrangements in the Chinese banking industry after the country's accession to the World Trade Organization (WTO). The restrictions imposed on foreign banks were not removed immediately after the WTO accession; they were gradually lifted over the first five years. The Chinese government believed that this arrangement would give their banking industry more time to meet the competition from the foreign banks.

[4] First, the policy documents are downloaded from the websites of each country. The questions in each mode of GATS is given a mark between zero and one according to the information in these documents, where one indicates that the banks' activities are fully restrictive and zero means no restrictions. Then, Dinh (2008) uses the principal component analysis to obtain the weight of each mode for the index of foreign or domestic banks. A similar methodology is employed by Barth et al. (2004) to construct indices of regulation and supervisory activities in 107 countries, using survey data in their analysis, which is the main difference from indices of Dinh (2008). The values of the indices are presented in the Appendix (Table A.1)

barrier indices on foreign banks (upper bar) are almost twice as much as that on domestic banks (lower bar).

[Figure 1 near here]

In order to investigate the efficiency effect of these two kinds of deregulation policies, i.e. relating to foreign or domestic banks, this paper assembles a dataset that covers the banking industries from 1997 to 2006 for seven Asian developing economies – China, Taiwan, India, Indonesia, Malaysia, Pakistan and Thailand.[5] First, the data envelopment analysis (DEA) approach is employed to evaluate the efficiency score of each bank in each year.[6] After obtaining the efficiency estimate, which is the DEA score, the effect that deregulation policies have on the banks' efficiency is studied by density analysis and regression analysis. The empirical results of this paper reveal that the deregulation of the operations of foreign banks has been effective in terms of efficiency gains. However, the converse, to remove the trade barriers on domestic banks, has had a much weaker effect than the deregulation policies for foreign banks. This finding is especially relevant to developing countries, such as China, India and Indonesia, where behind the impressive growth trajectory is a thirst for capital from firms.

The rest of the paper is organised as follows. Sections 2 and 3 introduce the data sources, selected variables, and methodology. Section 4 discusses the empirical results from the DEA and regression analyses and the sensitivity analyses are presented in Section 5. Section 6

[5] Mainland China and Taiwan are not merged in this analysis since they have different regulation and institutional systems. For brevity, China means Mainland China and Taiwan means the Taiwan province.

[6] Fethi and Pasiouras (2010) review a total of 196 studies in operational research and artificial intelligence techniques in the assessment of bank performance and find that 181 studies use DEA techniques to estimate various measures of bank efficiency or productivity growth, and the research based on the DEA-like techniques covers almost all of the banking industries around the world. There are several surveys or bibliographies in the literature (particularly Seiford, 1997; Gattoufi et al., 2004; and Emrouznejad, 2008) that list the DEA applications in other fields, such as education institutions, transport and logistics industry, agricultural sector, manufacturing industry, and so on. A similar methodology in this paper is employed by other researchers, such as Berger and Hannan (1998), Hermes and Nhung (2010), and Pasiouras (2008) to identify the impact of deregulation policies.

concludes the article and discusses implications for policy-makers.

2. Data

The data for efficiency evaluation are taken from financial statements provided by the Bankscope database of Bureau van Dijk. The original dataset consists of all financial institutions in the selected countries that appeared to have records, such as commercial banks, finance companies, securities firms, investment and trust corporations and group finance companies.[7] The index from Dinh (2008) only includes data relating to the services provided by commercial banks, so only data from commercial banks are kept. This provides a homogeneous dataset in terms of financial products provided, and consequently a standardised set of inputs and outputs, thereby enhancing further the comparability among countries.

Following previous research (Pasiouras et al., 2008 and Delis et al., 2011), the data are converted to millions of US dollars and deflated by the Consumer Price Index of each country. The financial statements prepared under international accounting or financial reporting standards have been used wherever possible, but the dataset also includes those prepared under local generally accepted accounting principles where these are the only ones available. Figure 2 illustrates the distribution of the observations in each country. Ultimately, the balanced dataset includes 810 observations from 81 banks from 1997 to 2006.

[Figure 2 near here]

Erecting a trade barrier is normally a country-level policy, but the DEA has to assume that

[7] There are two kinds of data used in this type of research – consolidated and unconsolidated. The data from consolidated financial statements include the combined information from banks and their subsidiaries, such as their insurance companies or financial companies, which are not directly related to the banks' main business. Thus, the unconsolidated dataset (the most common type in this dataset) is used but where it is not available, consolidated data are chosen instead.

the same technology is accessed by all banks in the dataset. This particular assumption has created a specific issue for the dataset used in this kind of analysis which imposes a heterogeneity factor on the dataset. The inclusion of several countries without considering heterogeneity would invalidate the assumption, so in this study seven Asian countries and regions are selected–China, Taiwan, India, Indonesia, Malaysia, Pakistan and Thailand. The common characteristics among these countries provide the primary motivation for choosing these economies – they are all Asian developing economies. The deregulation process in these seven economies is another motivation. Their indices change dramatically over the selected time span, which eases the identification in the regression analysis. For a similar reason, the technology is assumed unchanged in the selected time period from 1997 to 2006.[8]

Since commercial banks have diverse functions in the economy: to be the intermediation of funding, to be the financial product providers, or to maximise profit as a banking firm, one unanswered issue in the DEA model is that of input and output variable specification. Drake et al. (2009) demonstrate that the estimated efficiency score is highly dependent on the input and output variables utilised. In this analysis, the profit/revenue-based specification of the input and output variables is adopted, instead of the conventional production and intermediation specification. There are at least three reasons to select the profit/revenue-based specification, as follows.

First, the ideal raw data for the conventional product and intermediation specification are the number of the financial products or services provided by the management team in the banks, such as the number of bank accounts or the loans originated by each manager in each time period. Unfortunately, it is not possible to retrieve this kind of information from the financial reports of the banks. Second, the trade barriers could bias the results from the conventional

[8] The dataset is restricted by the availability of the deregulation index, which is available from 1997 to 2006.

production and intermediation specification. The policy restrictions strongly impair the number and range of products that each specific group of banks would like to provide. According to the estimation from Dinh (2008) in Figure 1, there are more trade barriers on foreign banks than that on domestic banks. In terms of the profit specification, bank managers have a relatively high level of freedom to adjust their internal management strategy to achieve higher revenue.[9] Third, the variables in the profit/revenue specification are a more rational choice than in the product or intermediation specification. For output variables, the other operating income is a proxy to reflect the income from other business, such as intermediary or off balance sheet business, and the net interest income is the proxy of the revenue that banks earned from the traditional business. These two variables derive purely from the profit function (Berger et al., 1993). The inputs are non-interest operating expenses for the daily operating costs and other operating expenses are the proxy for the rest of the cost. The total provisions are added to reflect the risk-taking behaviour of the banks. Table 1 shows the summary statistics of input and output variables.

[Table 1 near here]

Since the indices for trade barriers are the main explanatory variables of interest, other impacts from the industry and country level are controlled in the regression. The first controlled impact is that of the potential bargaining power of the whole banking industry on policy decisions.[10] The variable of bank concentration is added in the robustness test with the proxy of the development of the stock market. The number of publicly listed companies per 10,000

[9] Berger and Mester (2003) focus on the productivity change in the US banking sector over the period 1991–97, looking specifically at the changes in best practice and changes in efficiency. They find that the application of profit maximisation is superior to cost minimisation for studying bank performance, since it better reflects the economic goals of managers and owners, who take revenues into account as well as costs.

[10] The 'too big to fail' hypothesis states that large banks in monopolistic markets could be powerful enough to affect the policy decision, since the authorities are afraid of the bankruptcy of those big banks.

people is selected as the proxy for the stage of development of the stock market, which is taken from the database on The World Bank's Financial Development and Structure Dataset (Beck et al., 2000). Since the stability of the financial environment could influence bank efficiency, the Z-score from the same database is added as control variables. A larger value of the Z-score indicates higher bank market stability and lower systemic risk for the country.

At the country level, the natural logarithm of population size and gross domestic product (GDP) level are included due to the potentially positive relationships with bank efficiency. Using the dataset for 84 banking systems worldwide over the period 1987–2005, Delis (2012) finds that institutional development is the precondition for the success of financial reforms aimed at enhancing the efficiency of banking industries. Following his suggestion, the index of law and order from the International Country Risk Guide is included in the regression.[11] Table 2 presents the summary statistics of the independent variables and the observation is removed if there are missing values in the case of the country-specific control variables.

[Table 2 near here]

3. Methodology

In microeconomic theory, a bank is viewed as the firm that attempts to maximise an objective function for profit. Santomero (1984) argues that both the market environment and degree of regulation constrain the opportunity set of banks by restricting the domain of the solution, such as the portfolio of their assets or liabilities. In this paper, the DEA approach is employed to estimate the banks' capability to demonstrate their performance with respect to the 'opportunity set'. The inefficiencies of the banks are reflected by the DEA scores ($\widehat{TE}_{i,t}^{k}$) of bank k in country

[11] The International Country Risk Guide is published by Political Risk Services Group, which rates financial, political and economic risk. The index of law and order measures the integrity of the legal system. Their website is: http://www.prsgroup.com, accessed on 6 April 2013.

i in year t and are represented by the distance from the frontier (the most efficient production frontier, explained fully in the Appendix) to specific observation points. The further the distance from the frontier infers less efficiency.[12]

After that, the DEA score ($\widehat{TE}_{i,t}^{k}$) is assumed to be dependent upon its operating environment, such as the trade barrier ($\Delta Barrier_{i,t}$), the industry structure and the economic endowment of each country. In order to identify the effects of removing trade barriers on bank efficiency, the following linear model is assumed:

$$\Delta\widehat{TE}_{i,t}^{k} = \alpha_0 + \beta_1 \Delta Barrier_{i,t} + \beta_2 \Delta\overline{\widehat{TE}}_{i,t-1} + \beta_3 \Delta Control\ Var._{i,t} + \Delta\epsilon_{i,t}^{k} \quad (1)$$

$k = 1, \dots, n$ banks in country $i = 1, \dots 7$; and $t = 1, \dots, 10$

where $\Delta Barrier_{i,t}$, a vector of trade barriers on foreign or domestic banks in country i at time t, is assumed to exert an impact on the banks' efficiency ($\Delta\widehat{TE}_{i,t}^{k}$) via the estimated parameter β_1 and $\Delta\epsilon_{i,t}^{k}$ random errors. The $\Delta Control\ Var._{i,t}$ is the vector of control variables to partial out the impact from the industry and country level and α_0 is the constant term. The first difference model is employed for eliminating the unobserved time effect.[13]

The reverse causality issue is a drawback in using regression in this topic – there is a reverse causality whereby banking deregulation impacts on efficiency gains, while the promotion of

[12] The DEA score is an index that ranges from one to infinity, where the most efficient banks have a score of one. See section 7 the Appendix for further explanation.

[13] A similar 2SLS estimator is employed by Gonzalez (2009) and Delis et al. (2011). In the literature, some researchers consider the DEA scores to be the same as 'censored' data, and then do their modelling using the tobit model or the probit model. In the set of censored data, some of the observations are not used in the dataset since they are lower or higher than the threshold values. The observations are censored, which results in either knowing the exact value of an observation or in knowing that the value lies within an interval. However, DEA scores are very different from 'censored' data, so it is not appropriate to use DEA in a tobit or the probit model. For DEA scores, an inefficient observation is defined as any observation where the efficiency score is more than one (the minimum value and the left bound). It is defined as inefficient compared to the fully efficient observations in the dataset, which have an efficiency score exactly equal to one. Since the DEA score is not generated from the censoring process, McDonald (2009) argues that use of tobit or probit estimators is inappropriate in gaining insights in the application of DEA. Following his suggestion, the method of least squares is employed in the regression analysis, rather than the tobit model or probit model.

bank efficiency could encourage changes in the policy environment. Following the suggestion from Anderson and Hsiao (1981), the two-stage least-squares (2SLS) estimator is utilised and the average efficiency level of each country in previous period ($\Delta\overline{\widehat{TE}}_{i,t-1}$) is added to control for the bank efficiency in the previous period. The average of the penultimate efficiency level is used as the instrumental variable for that variable ($\Delta\overline{\widehat{TE}}_{i,t-1}$).

4. Empirical results

The focus of this paper is the distribution of the distance between the frontier and each observation, and this distribution is assumed to be impacted by the deregulation policies on removing trade barriers. Hence, the four most inefficient observations in Table 3 are removed in the following analysis since their DEA scores are more than four times the magnitude of the highest scores within the so-called cloud of the dataset and make the rest of data very ('super') efficient.[14]

[Table 3 near here]

Figure 3 presents the efficiency distribution with and without the very inefficient observations. The only difference between the two distributions is the long right tail in the chart on the left hand side, which is due to the included very inefficient outliers.[15]

[Figure 3 near here]

Table 4 reports the aggregated DEA scores in each country in each year and corresponding

[14] For instance, the DEA score of 12.152 from one of the banks in Thailand in 1998 shows that this particular bank is very inefficient.
[15] The adapted Li test (1,000 times in bootstrapping) from Simar and Zelenyuk (2006) is employed to double check whether the distribution is distorted by excluding the super inefficient observations from the cloud of the dataset. The calculated t statistic is 1.049 and the p-value is 0.117, which supports the null hypothesis (the two distributions are the same).

observation numbers. The average DEA score is 1.804 for observations, which implies that the profit could be increased at least 1.804 times on average compared with the fully efficient observations on the frontier. The most efficient banks in Table 4 are from Indonesia, followed by China and the worst performance is by the Taiwanese banks, specifically in 2005 and 2006. Pasiouras (2008) finds that in a 2003 sample of 95 countries, the average bank could improve its overall technical efficiency by 33.20 per cent, using the cross-section DEA. The figure of interest in this analysis, 1.804, is lower than the finding from Pasiouras (2008). The differences between these two results, i.e. the DEA score of 1.804 (or 55 per cent by 1/1.804) and 33.20 per cent, indicates that on average the banks in the selected countries are less efficient than the banks in the 95 countries.

[Table 4 near here]

In order to directly investigate the efficiency impact of removing trade barriers, the whole dataset is separated into three groups by the degree of deregulation, both for the foreign and domestic banks. The first group is the group with the toughest restrictions or the least deregulation in the market, referred to as the 'tough restriction' group. The group with the least restrictions includes the observations from the deregulated market, referred to as the 'least restriction' group. The group called 'average restriction' contains the observations from the group with an average degree of deregulation. The efficiency of these groups are presented in Table 5 for the restrictions on foreign banks and Table 6 for the restrictions on domestic banks.

[Table 5 near here]

The results in Table 5 show that the mean from the group of banks in the tough restriction environment (1.707) is smaller than the one of average restriction (1.752) and the group of banks in the least restriction environment (1.951), which is far from the general expectation.

Figure 4 shows the efficiency distributions of these three groups.[16] It is worth noting that the distribution of the least restriction group is the most flat group in all groups. The standard deviation in this group is almost twice that of the tough restriction group, suggesting that the trade barriers render the bank efficiency more concentrated about the mean. The deregulation activities result in the efficiency levels being much more evenly spread. Most of the banks in the least restricted group are shown to be very efficient, and relatively few of them are inefficient.

[Figure 4 near here]

Table 6 and Figure 5 present the summary statistics and efficiency distributions by level of deregulation for domestic banks. The means of these groups are all around 1.80 and the standard deviation is about 0.52. The distributions of these groups are shown to be very similar. The efficient and inefficient banks are not concentrated in any particular group, which could indicate that the impact of deregulation on bank efficiency is relatively weak.

[Table 6 near here]

[Figure 5 near here]

In order to examine whether the deregulation policies distort the efficiency distributions in the different groups, the adapted Li (1996) test by Simar and Zelenyuk (2007) is used to compare the distribution of each of the groups and the results are shown in Table 7. The null hypothesis of the test is that two distributions are the same, which is rejected across all groups,

[16] There is a specific issue for the density estimation to deal with the DEA scores, since the value range of the scores is from one to positive infinite, which is not suitable to create a normal distribution density. Taking up the suggestion from Simar and Zelenyuk (2006), the issue of the boundary in the DEA score is solved by the Silverman reflection method and the bandwidth is selected by the Sheather and Jones (1991) method in Gaussian kernel. A similar analysis can be found in the paper by Valverde et al. (2007).

except for the test on the group of least versus tough regulation of domestic banks. The t-value of the test on this group is 1.176 and the p-value is 0.078, which implies that it is not possible to say with confidence that the two distributions are significantly different.

[Table 7 near here]

Table 8 and Table 9 report the baseline estimates based on Equation (1). The dependent variable in the regression is the change in bank-level DEA scores ($\widehat{TE}_{i,t}^{k}$) and the hypothesised explanatory variable represents the trade barriers affecting foreign or domestic banks. Table 8 shows the results for the regression on foreign banks. Columns (1) and (2) report the estimate from a simple pooled regression of the bank efficiency on trade barriers without taking into account the confounding effects related to banks, unobserved country heterogeneity and macroeconomic shocks. The coefficient value on trade barriers fluctuates from 0.635 in column (1) to 0.046 in column (2). The positive correlation means that reducing the trade barriers could increase the efficiency of the banks. Although the regression results from the simple pooled regression is unidentified, it provides a starting point to understand how omitting bank, country and year level confounders may influence the qualitative interpretation of the econometric analysis.[17]

[Table 8 near here]

The first difference model is employed in columns (3) and (4) to address the issue of the bias in the simple pooled regression, which has the same function as the fixed effect model in the panel data analysis. The result from the simple pooled regression continues to hold and become stable from 2.878 in column (3) to 3.063 in column (4) of Table 8. However, the sign

[17] For example, banks follow different risk management strategies or asset-liability management systems, which are constant to the individual bank, but different in each bank in the dataset.

of average efficiency level in the previous period ($\overline{\widehat{TE}}_{i,t-1}$) is far from the general expectation in column (3) due to the potential autocorrelation between the efficiency score in the previous period ($\widehat{TE}^{k}_{i,t-1}$) and in the current period ($\widehat{TE}^{k}_{i,t}$). In order to response to the autocorrelation issue, the regression results from the 2SLS estimator are presented in column (4) and the average of the two period lag efficiency level ($\Delta\overline{\widehat{TE}}_{i,t-2}$) is used as the instrument for the endogenous variable ($\overline{\widehat{TE}}_{i,t-1}$).

With regard to the efficiency effect from removing trade barriers on domestic banks, the only significant coefficient is in column (1) of Table 9 from the pooled OLS model and the negative sign indicates that the bank efficiency is reduced by removing the trade barriers for domestic banks, which is in the opposite direction to the expectation. For the reasons discussed above, the results from the OLS are not considered to be consistent.[18] Column (3) and column (4) provide the estimation results from the first difference model which controls the variations between time and bank factors. The 2SLS estimator is employed in column (4), and the value of the results is between 1.540 in column (3) and 2.836 in column (4), but still not statistically significant.

[Table 9 near here]

5. Sensitivity analyses

The empirical results in the baseline model are highly robust in a battery of sensitivity tests that attempt to separate out the impacts from specific important factors relating to industry and country characteristics, such as the index of bank concentration, the development of the stock

[18] Variations between banks and across years need to be removed before identifying the impact from the deregulation policies.

market, and GDP level.[19] The results are shown in Tables 10 and 11 for foreign and domestic banks, respectively. In column (1) of Table 10 and Table 11, the bank concentration and the average efficiency level of the previous period are added to diminish the impacts from the industry structure on the efficiency. Following Kravtsova's suggestion (Kravtsova, 2008), the size of population and GDP level are added in column (2). The full model in column (6) contains all control variables. As shown in Table 10, the deregulation policies on foreign banks is still significant and stable with a value from 3.084 to 3.557.[20]

[Table 10 near here]

In Table 11, the efficiency level of the previous period ($\Delta\overline{\overline{TE}}_{i,t-1}$) is the most significant variable affecting the efficiency of domestic banks, which means that the further the banks are away from the frontier, the easier it is for them to move towards the frontier. The coefficient of the impact of removing trade barriers on domestic banks is not statistically significant. This result is consistent with the evidence from the density estimation in section 4.[21]

[Table 11 near here]

6. Concluding remarks

Relying on bank level data, this paper contributes to the literature by utilising recently developed methods in efficiency analysis to investigate the efficiency gains from removing trade barriers on banking performance in seven Asian developing economies from 1997 to 2006. The indices of Dinh (2008) serve as proxies for deregulation policies related to the

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[19] The three-period lag efficiency levels are used as the instrument in the 2SLS estimator. The results are available on request.

[20] Zelenyuk (2009) points out that it is usual for this kind of model to yield low significance of coefficients, which indicates the effect could be very large in reality if the results are significant.

[21] The distribution is almost identical in these three groups that are classified by the level of deregulation of domestic banks.

removal of trade barriers on foreign and domestic banks. Particularly, the deregulation policies are classified as two types: (1) the deregulation of the domestic banking industry to allow for foreign banks to carry out business more freely; (2) the deregulation of domestic banks to allow these banks to carry out business more freely.

After obtaining the efficiency estimate for each bank in the DEA approach, the whole dataset is separated into three groups by the level of trade barriers on the banking industries. The density analysis reveals that the deregulation polices for foreign banks distort the distribution shapes in the group with the least trade barriers on foreign banks, but the deregulation policies for domestic banks does not have the same impact on the shapes of the distributions.

This result from the density analysis is consistent with the regression results, which also suggest that policies to deregulate domestic banks only may have less of an impact on efficiency than the policies to deregulate foreign banks. In terms of increasing bank efficiency, the policy of deregulating foreign banks could be an effective policy for developing countries. Nonetheless, it is understandable from the policy-maker’s perspective that deregulation of foreign banks may have some unwanted consequences. For instance, the entry of foreign banks may be perceived to carry a degree of risk for the financial system, since it makes the whole system more susceptible to international capital flows and speculations. Deregulation of foreign banks exposes the host country to prudential regulations of foreign countries, which may have less stringent requirements. These issues of risk management related to bank deregulation are interesting in their own right and certainly important for policy-makers as they need to weigh up the benefits of deregulating foreign banks, which this paper has shown to be a powerful way of raising bank efficiency, against the risks that may accompany such a policy.

7. Appendix

In this appendix, the DEA model is briefly outlined for completeness sake. For a more in-depth description, the reader is referred to Cooper et al. (2011).

DEA is a 'data-oriented' approach for evaluating the performance of a set of entities called decision-making units (DMUs) which convert multiple inputs into multiple outputs. The meaning of technical efficiency is borrowed from the concept of Debreu (1951) and Farrell (1957), which is defined as 'one minus the maximum equi-proportionate reduction in all inputs that still allows continued production of given outputs'. Based on their concept and the convexity assumption, Charnes et al. (1978; 1979), Deprins et al. (1984) and Färe et al. (1985) developed the DEA model to measure efficiency relative to a non-parametric, maximum likelihood estimate of an unobserved but true frontier.

The DEA is carried out by estimating the most efficient production frontier using all bank-year observations. The efficiency level derived from the most efficient 'frontier banks' will then provide the reference point for comparing how efficient the other banks are relative to the frontier. The relative efficiency of a bank is expressed by the DEA score, which ranges from one to infinity. The 'frontier banks' will have a DEA score of one, while increasingly inefficient banks will have increasingly larger DEA scores. Given that the production process may be heterogeneous across countries, the DEA approach has the advantage of being a non-parametric estimation procedure. In other words, it does not require prior knowledge of the actual functional form (such as Cobb–Douglas) affecting the operation, and therefore the efficiency, of the banks.

The DEA score can be estimated in the input or output direction. The input direction measures the proportional reduction in input quantities without changing the output quantities produced. The output direction measures the proportional increase in the output quantities produced without altering the input quantities employed. To be consistent with the microeconomic theory of banking, the output direction is selected and the grand frontier of the maximum outputs is created first, as per the assumption that commercial banks maximise their profits by using their inputs effectively.[22]

The empirical specification is given by the following frontier model (illustrated in the output direction). The first fundamental assumption is that all banks have access to the same production set, which is denoted as Ψ. Inputs x in any bank can be freely obtained in the long run (or during the entire time period). Production set Ψ of physically attainable points (x, y) is given by:

$$\Psi = \left\{(x, y) \in R_{+}^{p+q} \middle| x \text{ can produce } y\right\} \tag{2}$$

This production set includes any possible input and output combination from the observations, which can be described by the corresponding output set.

$$Y(x) = \left\{y \in R_{+}^{q} \middle| (x, y) \in \Psi\right\} \text{ defined } \forall x \in \Psi \tag{3}$$

This set means that all possible output y can be found in the production set Ψ if any corresponding input x ($x \in \Psi$) is given. The basic idea of DEA is to estimate the attainable set Ψ by its subset $\widehat{\Psi}$ ($\widehat{\Psi} \in \Psi$) that envelops all observations. The boundary enveloping all observations is called the Farrell efficiency boundary, defined as $\partial Y(x)$, since it meets all requirements of the concept of technical efficiency from Debreu (1951) and Farrell (1957).

[22] In the analysis by Delis et al. (2011), the output-direction Malmquist indices are estimated using separate frontiers for 22 transition countries, which indicates that the technology is varied across countries. In this analysis, the grand frontier is created based on all observations from each country over the period 1997–2006, and all banks from different countries are assumed to have access to the same technology, which allows the DEA scores to be compared among different countries in the regression analysis. The constant returns to scale frontier is adopted in order to reflect the potential efficiency gains from the economies of scale since the trade barriers are expected to change the product lines of banks and encourage the development of commercial banks to achieve the optimal size.

$$\partial Y(x) = \{y | y \in Y(x), \beta y \notin Y(x)\ \forall \beta > 1\} \quad (4)$$

The main feature of this subset is that β cannot be larger than one, and the intuition is that any value over one (for β) will increase the size of the output value and make it outside of the production set. In other words, given the input x, the output y is already the maximum level. The Farrell efficiency boundary is a subset of the production set. Any deviation in other observations under that boundary is due to the Farrell technical inefficiency, as:

$$\beta(x, y) = \sup\{\beta > 0 | \beta y \in Y(x)\} \quad (5)$$

Given the direction and maximum output, all other observations from each bank in each year will be marked by that distance (β) from the boundary ($\partial Y(x)$). The Farrell technical inefficiency ($\beta(x, y)$) could be transformed to the Shephard distance function so as to be readily interpreted and dealt with, such as

$$\delta_{Output}(x, y) = (\beta(x, y))^{-1} = inf\{\delta > 0 | \tfrac{y}{\delta} \in Y(x)\} \quad (6)$$

$\delta_{Output}(x, y) = 1$ means that the observation is on the frontier (or $(x, y) \in \partial Y(x)$). Otherwise, $\delta_{Output}(x, y) > 1$ is interpreted as the maximum feasible proportionate augmentation of outputs for that observation $(x, y) \in \Psi$. In order to evaluate the parameter in this model, the following requirement set is calculated by the linear programming technique.

$$\widehat{\Psi} = \{(x, y) \in R^{p+q} | y \leq \textstyle\sum_{i=1}^{n} \gamma_i y_i\, , x \geq \sum_{i=1}^{n} \gamma_i x_i, \quad (7)$$
$$\textstyle\sum_{i=1}^{n} \gamma_i = 1\, , \gamma_i \geq 0, i = 1,2, \dots n\}$$

In this estimated set, all observations are enveloped by the observations on the boundary and the projected point $(x\ , y)$ is a linear combination of observations on the frontier. Thus, $\widehat{\Psi}$ is the smallest convex free-disposal hull that fits all observed data, and its upper boundary is a piece-wise linear estimate of the theoretical frontier. The estimated set ($\widehat{\Psi}$) could be calculated under two assumptions: constant returns to scale (CRS) or the varied returns to scale (VRS). The assumption of CRS assumes that the DMUs or banks in this paper are automatically working in their scale efficient size and the efficiency frontier is a plane. The VRS assumes that the DMUs could be achieving increasing returns to scale at low output levels and vice versa. Thus, the frontier in the assumption of VRS is a convex hull. In this paper, the VRS assumption is adopted and the constraint of VRS is ensured by $\sum_{i=1}^{n} \gamma_i = 1$.[23] The DEA score is estimated by the following linear programming algorithm:

$$(\hat{\delta}_{Output}(x,y))^{-1} = \max\{\beta \mid \beta y \leq \sum_{i=1}^{n} \gamma_i y_i \,, x \geq \sum_{i=1}^{n} \gamma_i x_i, \sum_{i=1}^{n} \gamma_i = 1, \quad \gamma_i \geq 0, \beta > 0, i = 1, \dots n\} \tag{8}$$

The $\hat{\delta}_{Output}(x,y)$ is evaluated for each observation, denoted as $\widehat{TE}_{i,t}^{k}$, and it is regressed with the trade barrier indices (the hypothesised explanatory variable) in Table A.1.

[23] γ_i is a $n \times 1$ vector of radial constants of the input and output vector, and that constraint is modified in the CRS assumption.

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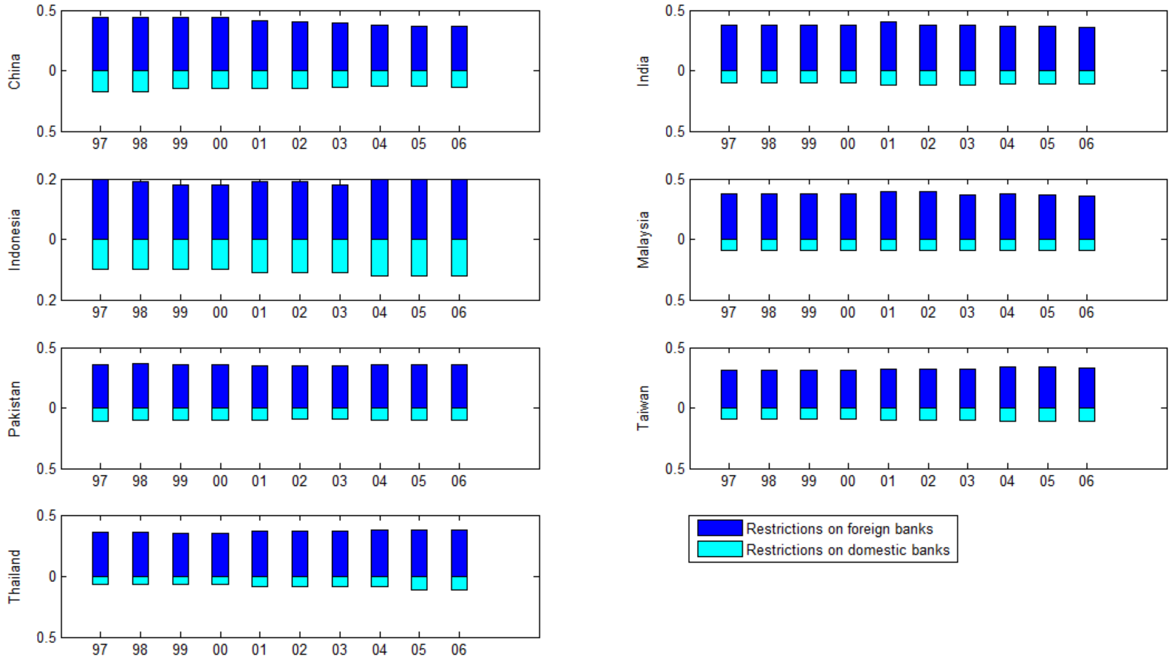

Figure 1. Trade barrier indices of foreign and domestic banks

Source: Dinh (2008).

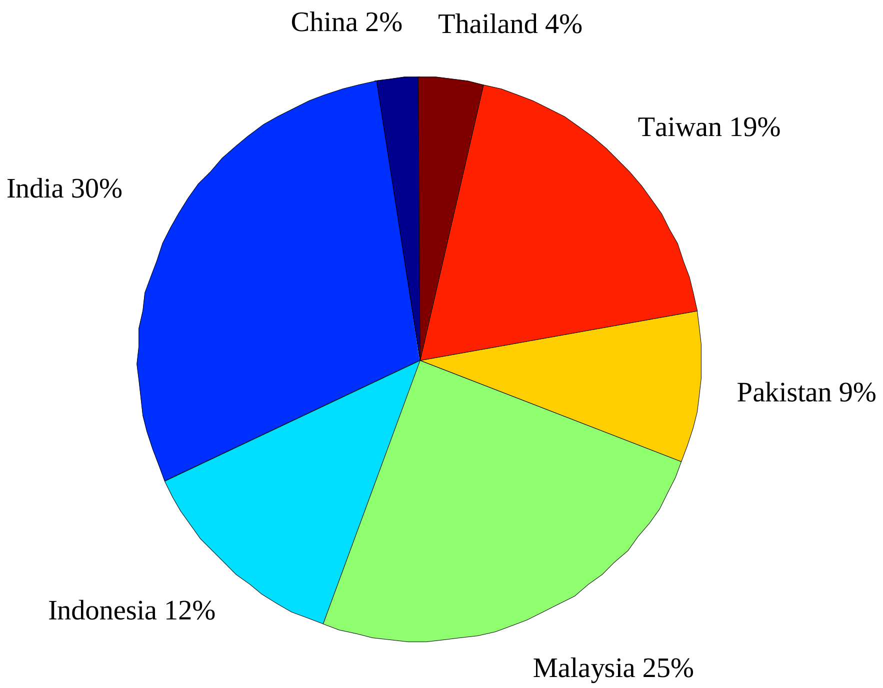

Figure 2. Percentage of the observations from each country

Source: Author's calculations.

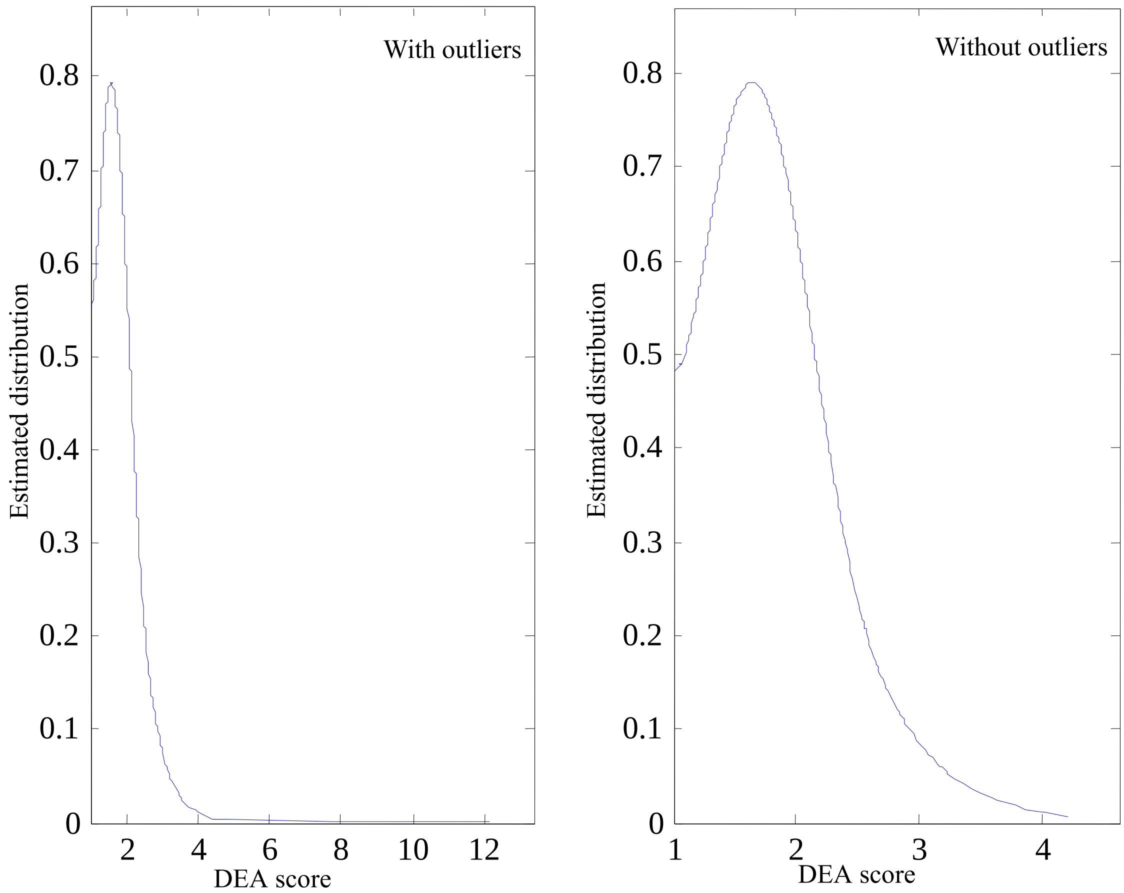

Figure 3. Distribution of DEA score with or without outliers

Source: Author’s calculations.

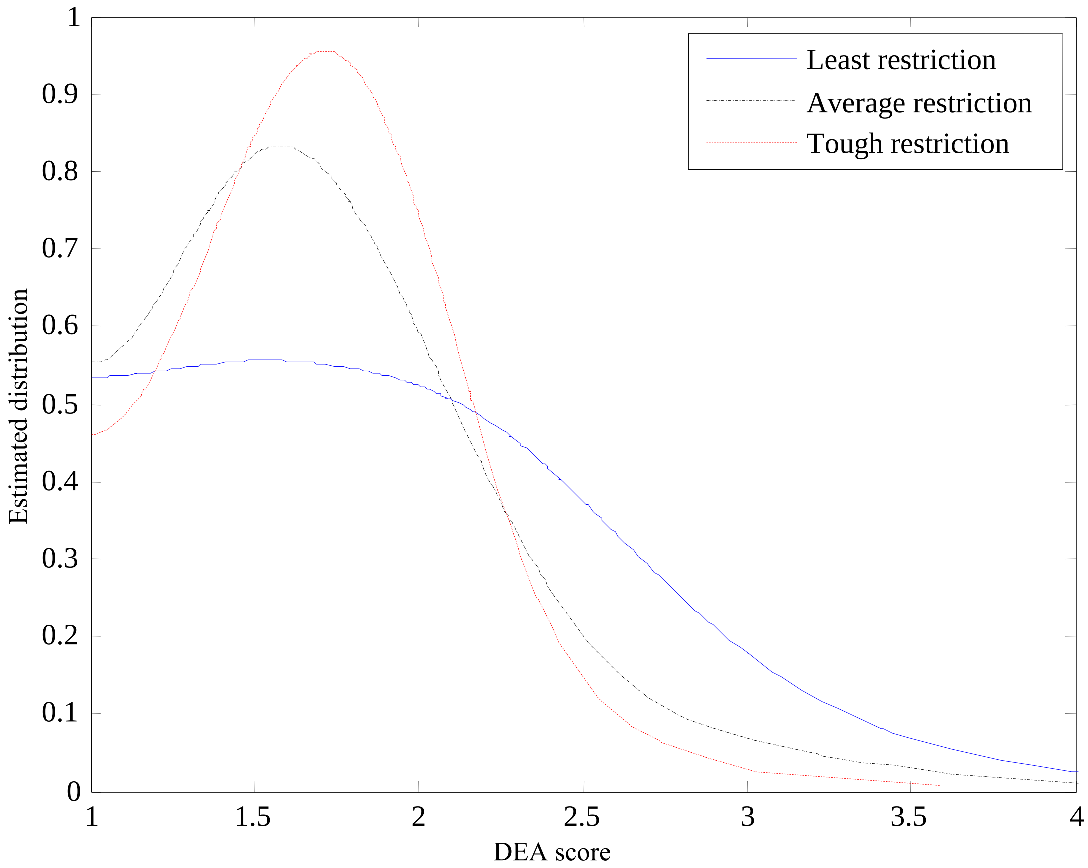

Figure 4. Distribution of restriction groups of foreign banks (1997–2006)

Source: Author's calculations.

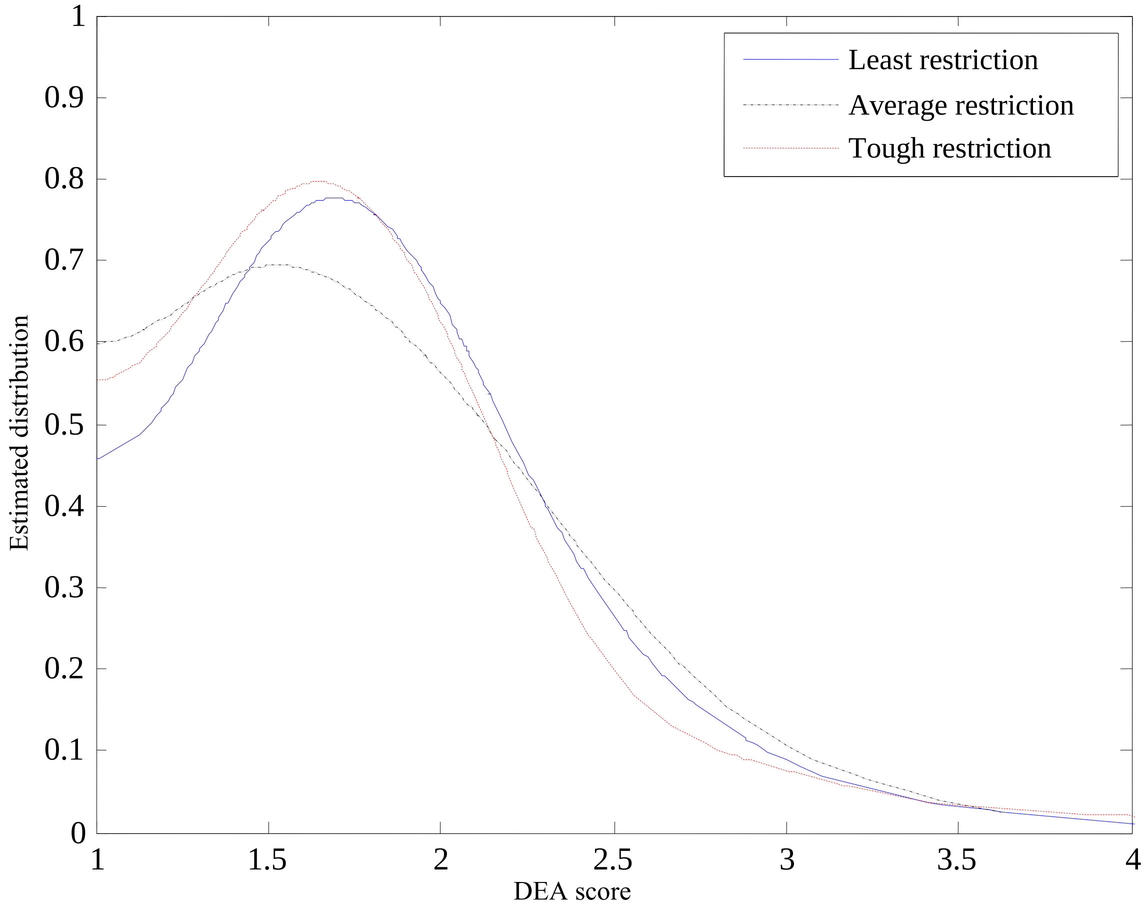

Figure 5. Distribution of restriction groups of domestic banks (1997–2006)

Source: Author's calculations.

Table 1. Summary statistics of input and output variables (US$ million)

Type	Variables	Mean	S.D.	Min.	Max.
Input	Non-interest operating expenses	135.58	168.61	0	1,099.90
	Total provisions	156.57	159.65	0	1,910.58
	Other operating expenses	78.10	116.92	0	948.16
Output	Other operating income	57.92	45.48	0	637.83
	Net interest income	218.12	285.57	0	2,110.84

Source: Author's calculations.

Table 2. Summary statistics of independent variables

Variable	Mean	S.D.	Min.	Max.
Restrictions on foreign banks	0.34	0.06	0.18	0.44
Restrictions on domestic banks	0.10	0.01	0.07	0.17
Bank concentration (index)	0.40	0.11	0.25	0.82
Stock no. (per 10,000 people)	0.16	0.15	0.01	0.53
Law and order (index)	2.41	0.72	1.00	4.00
Z score (index)	8.71	3.98	1.13	48.96
Population (1,000 people)	392,946	462,044	21,407	1,304,262
GDP growth (US$ million)	8,154.13	7,957.89	1,678.92	28,031.01

Source: Author's calculations.

Table 3. Super-inefficient observations in the dataset

Year	Country	$\Delta\widehat{TE}_{i,t}^{k}$	Non-interest operating expenses	Total provisions	Other operating expenses	Net interest income	Other operating income
1997	Pakistan	7.752	267.59	237.73	193.85	21.77	13.07
1998	Thailand	12.152	662.34	1,322.34	405.65	23.24	246.54
2000	Thailand	4.796	546.06	829.98	356.10	27.25	552.40
2006	Taiwan	4.416	139.18	509.29	77.44	9.66	197.42

Note: $\Delta\widehat{TE}_{i,t}^{k}$ is the DEA score for the banks and a value of more than one means inefficiency, since one indicates full efficiency.
Source: Author's calculations.

Table 4. The average DEA score in each country

Name	Obs.	1997/98	1999/2000	2001/02	2003/04	2005/06	Average DEA score
China	20	1.438	1.884	1.710	1.494	1.267	1.559
Taiwan	150	2.128	2.264	2.544	2.118	2.677	2.344
India	240	1.690	1.690	1.761	1.742	1.657	1.708
Indonesia	100	1.267	1.333	1.391	1.483	1.630	1.421
Malaysia	200	1.590	1.735	1.878	1.703	1.688	1.719
Pakistan	70	1.743	1.791	1.808	1.589	1.511	1.688
Thailand	30	2.469	2.457	2.301	1.989	1.794	2.184
Period average		1.717	1.801	1.912	1.760	1.828	1.804

Source: Author's calculations.

Table 5. DEA efficiency of restriction groups of foreign banks (1997–2006)

Groups	Mean	Median	S.D.	Max.
Least restriction	1.951	1.887	0.644	4.199
Average restriction	1.752	1.671	0.491	4.007
Tough restriction	1.707	1.704	0.381	3.589

Note: The minimum value (one) is not shown in the table, since it indicates full efficiency.
Source: Author's calculations.

Table 6. DEA efficiency of restriction groups of domestic banks (1997–2006)

Groups	Mean	Median	S.D.	Max.
Least restriction	1.827	1.756	0.505	4.007
Average restriction	1.809	1.744	0.536	3.625
Tough restriction	1.775	1.707	0.540	4.199

Note: The minimum value (one) is not shown in the table, since it indicates full efficiency.
Source: Author's calculations.

Table 7. Adapted Li test of restrictions on efficiency distribution (1997–2006)

Groups	Foreign banks	Domestic banks
Least/average	Reject H_0	Reject H_0
	13.081	3.420
	(p-value: 0.000)	(p-value: 0.004)
Average/tough	Reject H_0	Reject H_0
	3.840	3.242
	(p-value: 0.000)	(p-value: 0.004)
Least/tough	Reject H_0	Retain H_0
	23.482	1.176
	(p-value: 0.000)	(p-value: 0.078)

Notes: 1. H_0 is that two distributions are identical. 2. The grand frontier is estimated using all observations and the result is based on 1,000 replications in the stage of bootstrapping.
Source: Author's calculations.

Table 8. Benchmark regression on foreign banks

Dependent variables	$\widehat{TE}_{i,t}^{k}$	$\widehat{TE}_{i,t}^{k}$	$\Delta\widehat{TE}_{i,t}^{k}$	$\Delta\widehat{TE}_{i,t}^{k}$
Model	Pooled OLS	Pooled OLS	First difference	2SLS
	(1)	(2)	(3)	(4)
Barrier on	0.635	0.046	2.878**	3.063**
foreign banks	(0.617)	(0.500)	(1.455)	(1.494)
$\overline{\widehat{TE}}_{i,t-1}$		0.635***	-0.034	0.449
		(0.075)	(0.090)	(0.361)
Constant	1.584***	0.659***	0.008	0.001
	(0.216)	(0.209)	(0.014)	(0.015)
Observations	803	719	638	638
(No. of banks)	(81)	(81)	(81)	(81)

Notes: 1. The first difference model is employed in column (3) and (4); 2. Standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.10
Source: Author's calculations.

Table 9. Benchmark regression on domestic banks

Dependent variable	$\widehat{TE}_{i,t}^{k}$	$\widehat{TE}_{i,t}^{k}$	$\Delta\widehat{TE}_{i,t}^{k}$	$\Delta\widehat{TE}_{i,t}^{k}$
Model	Pooled OLS	Pooled OLS	First difference	2SLS
	(1)	(2)	(3)	(4)
Barrier on	-4.083***	-0.601	1.540	2.836
domestic banks	(1.471)	(1.532)	(2.430)	(2.627)
$\overline{\widehat{TE}}_{i,t-1}$		0.627***	-0.034	0.546
		(0.077)	(0.091)	(0.363)
Constant	2.217***	0.750***	0.010	0.003
	(0.156)	(0.236)	(0.014)	(0.015)
Observations	803	719	638	638
(No. of banks)	(81)	(81)	(81)	(81)

Notes: 1. The first difference model is employed in column (3) and (4). 2. Standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.10
Source: Author's calculations.

Table 10. Efficiency gains from removing trade barriers on foreign banks

Dependent variable	$\Delta\widehat{TE}_{i,t}^{k}$	$\Delta\widehat{TE}_{i,t}^{k}$	$\Delta\widehat{TE}_{i,t}^{k}$	$\Delta\widehat{TE}_{i,t}^{k}$	$\Delta\widehat{TE}_{i,t}^{k}$	$\Delta\widehat{TE}_{i,t}^{k}$
Mode: 2SLS	(1)	(2)	(3)	(4)	(5)	(6)
Barrier on	3.087**	3.084*	3.139**	3.248**	3.340**	3.557**
foreign banks	(1.557)	(1.678)	(1.573)	(1.563)	(1.532)	(1.619)
$\Delta\overline{\widehat{TE}}_{i,t-1}$	0.446	0.859*	0.531**	0.467*	0.448	0.815**
	(0.375)	(0.455)	(0.263)	(0.268)	(0.273)	(0.395)
Bank concentation$_{t-1}$	0.019	-0.142	-0.006	-0.018	0.028	-0.108
	(0.362)	(0.410)	(0.355)	(0.352)	(0.343)	(0.375)
Stock no $_{t-1}$			0.455	0.622	0.652	-0.468
			(0.734)	(0.745)	(0.749)	(1.100)
Law & order $_{t-1}$				-0.051	-0.063*	-0.100**
				(0.035)	(0.035)	(0.040)
Z score $_{t-1}$					-0.003	-0.003
					(0.004)	(0.005)
log Population $_{t-1}$		-2.328				-4.302
		(2.291)				(2.907)
log GDP $_{t-1}$		0.694				0.771
		(0.591)				(0.513)
Constant	0.001	0.012	-0.004	-0.010	-0.010	0.038
	(0.016)	(0.051)	(0.015)	(0.015)	(0.015)	(0.051)
Observations	638	638	638	638	634	634
(No. of banks)	(81)	(81)	(81)	(81)	(81)	(81)

Notes: 1. *Bank concentration* is assets of three largest banks as a share of assets of all commercial banks. 2. *Stock no* is the number of publicly listed companies per 10,000 population. 3. Standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.10.
Source: Author's calculations.

Table 11. Efficiency gains from removing trade barriers on domestic banks

Dependent variable	$\Delta\widehat{TE}_{i,t}^{k}$	$\Delta\widehat{TE}_{i,t}^{k}$	$\Delta\widehat{TE}_{i,t}^{k}$	$\Delta\widehat{TE}_{i,t}^{k}$	$\Delta\widehat{TE}_{i,t}^{k}$	$\Delta\widehat{TE}_{i,t}^{k}$
Model: 2SLS	(1)	(2)	(3)	(4)	(5)	(6)
Barrier on	2.663	2.838	2.730	3.130	1.464	2.083
domestic banks	(2.641)	(2.774)	(2.616)	(2.606)	(2.560)	(2.799)
$\Delta\overline{\widehat{TE}}_{i,t-1}$	0.563	0.975**	0.609**	0.543**	0.555**	0.939**
	(0.373)	(0.455)	(0.260)	(0.264)	(0.274)	(0.401)
Bank concentration$_{t-1}$	-0.153	-0.321	-0.166	-0.176	-0.175	-0.337
	(0.351)	(0.396)	(0.346)	(0.343)	(0.336)	(0.368)
Stock no $_{t-1}$			0.246	0.415	0.380	-0.780
			(0.733)	(0.741)	(0.755)	(1.128)
Law & order $_{t-1}$				-0.052	-0.061*	-0.104**
				(0.036)	(0.035)	(0.041)
Z score $_{t-1}$					-0.002	-0.003
					(0.004)	(0.005)
ln Population $_{t-1}$		-1.970				-4.216
		(2.329)				(3.046)
ln GDP $_{t-1}$		0.822				0.931*
		(0.587)				(0.516)
Constant	0.002	0.003	-0.001	-0.007	-0.008	0.034
	(0.016)	(0.051)	(0.015)	(0.016)	(0.016)	(0.054)
Observations	638	638	638	638	634	634
(No. of banks)	(81)	(81)	(81)	(81)	(81)	(81)

Notes: 1. *Bank concentration* is assets of three largest banks as a share of assets of all commercial banks. 2. *Stock no* is the number of publicly listed companies per 10,000 population. 3. Standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.10.
Source: Author's calculations.

Appendix

Table A.1. Trade barrier indices (1997–2006)

Country	Type	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	Average
China	Foreign	0.44	0.44	0.44	0.44	0.41	0.40	0.39	0.38	0.37	0.37	0.408
	Domestic	0.17	0.17	0.15	0.15	0.15	0.15	0.14	0.13	0.13	0.14	0.148
India	Foreign	0.38	0.38	0.38	0.38	0.40	0.38	0.38	0.37	0.37	0.36	0.378
	Domestic	0.10	0.10	0.10	0.10	0.12	0.12	0.12	0.11	0.11	0.11	0.109
Indonesia	Foreign	0.20	0.19	0.18	0.18	0.19	0.19	0.18	0.20	0.20	0.20	0.191
	Domestic	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.12	0.12	0.12	0.109
Malaysia	Foreign	0.38	0.38	0.38	0.38	0.39	0.39	0.37	0.38	0.37	0.36	0.378
	Domestic	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.090
Pakistan	Foreign	0.36	0.37	0.36	0.36	0.35	0.35	0.35	0.36	0.36	0.36	0.358
	Domestic	0.11	0.10	0.10	0.10	0.10	0.09	0.09	0.10	0.10	0.10	0.099
Taiwan	Foreign	0.31	0.31	0.31	0.31	0.32	0.32	0.32	0.34	0.34	0.33	0.321
	Domestic	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.11	0.11	0.11	0.099
Thailand	Foreign	0.36	0.36	0.35	0.35	0.37	0.37	0.37	0.38	0.38	0.38	0.367
	Domestic	0.07	0.07	0.07	0.07	0.09	0.09	0.09	0.09	0.11	0.11	0.086

Source: Dinh (2008).