Cost Efficiency Analysis in Banking Industries of Ten Asian Countries and Regions

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Abstract

The existing literature of banking efficiency analysis under international comparison is mostly limited to the US and European Union. No study was found in Asian countries and regions due to the difficulty of collecting data and other issues. This paper will be one of the first to address this issue and add into the literature. Cross-country studies are conducted by setting up a common frontier to measure the relative efficiency score. However, due to the different geographic, economic and financial characteristics, differences of managerial abilities within the banks may not be the only reason to explain the observed difference of banking efficiency scores. Therefore, in setting up the common frontier as benchmark, the cross-country heterogeneous factors cannot be excluded. In our empirical results, based on the consistent panel data estimating models, we find that, when heterogeneity is considered, the efficiency score is higher than when it is not included, which suggests that the heterogeneity explains part of the inefficiency and neglecting heterogeneity in cross-country studies will generate underestimated efficiency score. We also find that China only ranks fourth after India, Singapore and Malaysia, which suggest that we still have to improve the managerial performance of the banking sector to achieve robust competitive power in the international stage.

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1. Introduction

The idea of technical efficiency was first addressed by Farrell (1957), who introduced a method to decompose the overall efficiency of a production unit into its technical and allocative components. A firm is said to be inefficient either by producing less than maximum output from a given set of inputs or using more than the minimum input required for a given level of output (technical inefficient) or by utilizing the wrong mix of input given their prices (allocative inefficient). In the following 50 years, huge amount of efficiency studies emerge in the literature in which technical efficiency are measured by building up the production frontier. If more information on input prices or revenue side is attainable, cost efficiency or profit efficiency can be measured as dual of the technical efficiency. The cost efficiency analysis measures the extent to which a bank's cost is close to the "best" performed bank for a given level of output in the same conditions. It is derived from a cost function in which the total costs of a bank depend on the certain amount of outputs, prices of inputs involved, environmental variables, random errors and efficiency. The profit efficiency measures how close a bank is to producing the maximum possible profit given a particular level of input prices and output prices (and other variables). It can be measured in the similar way as the cost efficiency by replacing some specific variables on both dependent and independent sides.

In the last two decades, the efficiency and productivity analysis of the banking industry has been investigated extensively. The emphasis of this area now spreads widely from scale and scope economies to the cost and profit efficiency. These studies apply the non-parametric methods such as the data envelopment analysis (DEA) and parametric methods such as the stochastic frontier approach (SFA) to discuss the various issues in the efficiency measurement, for example issues of informing government policy like deregulation, merger and acquisition, problem loans and managerial performance, as well as addressing methodology issues and international comparisons.

Like most studies that focus on the banking industry of a specific country, the studies of international comparison employ the efficiency measurement in the developed US and European market. Studies in Asian countries and regions are limited and no international comparison in Asian countries and regions can be found due to the lack of the satisfactory quality data, development of the whole economy and financial system and other issues. Therefore, our paper will be the first to address this issue and add into the literature. Besides, with entering the WTO and opening of financial market to foreign financial institutions, from the policy perspectives, we are eager to know the efficiency level and the competitiveness of Chinese banking industry against the challenge of the foreign banks especially from our neighbors.

From the existing literature of cross-country studies, we found that due to different geographical and macro economic conditions, countries differ from each other substantially. As a result, differences of managerial abilities within the banks may not be the only reason to explain the observed differences in banking efficiency score. Therefore, in setting up the common frontier as benchmark, the cross-country heterogeneous factors cannot be excluded. Our paper, along with some current cross-country studies, takes account of the effect of the cross-country heterogeneity on the cost efficiency scores. In our empirical results, we find that, when cross-country heterogeneity is considered, the efficiency score is higher than when it is not included, which suggests that the heterogeneity explains part of the inefficiency and neglecting heterogeneity in cross-country studies will generate underestimated efficiency score.

Moreover, in the estimating perspective, our paper is among the first to adopt the panel data stochastic frontier approach in an attempt to measure its cost efficiency. Efficiency scores in the previous cross-country studies are estimated using SFA under a cross sectional basis, which suffers a few shortcomings such as strong distributional assumption on the inefficiency term, uncorrelatedness of the inefficiency term with the regressors, no time-varying inefficiency, inconsistent estimates of the inefficiency term. As suggested by Schmidt and Sickles (1984), these drawbacks can be solved by using the panel data framework.

The structure of this paper is organized as follows. Section 2 will review the existing cross-country studies that shed light on the motivation of this paper. In Section 3 panel data stochastic frontier methodology will be introduced in detail. Section 4 presents the data along with the output and input specifications. In section 5, empirical results will be discussed with section 6 to conclude.

2. Cross-country comparison-a brief literature review

Review of cross-country studies was only addressed in Berger and Humphrey (1997), in which the authors did a thorough survey that covers 130 studies applying the frontier efficiency analysis to financial institutions in 21 countries. Six cross-country comparisons are reviewed with five of them based on the non-parametric approaches such as DEA and two of them based on the parametric approaches such as distribution free approach (DFA) and thick frontier approach (TFA). No other dedicated survey of cross-country efficiency studies can be found.

Table 1 surveys fourteen cross-country studies with summary of some key features that will shed light on our own interests.

Insert Table 1 here

2.1 Applied countries of cross-country studies

In 1990s, two studies measure and compare the technical efficiency of banking firms. One concentrates on three Nordic countries and the other on 8 EU countries. Twelve other cross-country studies focus on the cost efficiency and profit efficiency, which suggests that the heart of the efficiency analysis has now shifted to cost and profit efficiency, indicating that researchers should evaluate the managerial performance of a banking firm from the cost side and the revenue side. Nine of them make a comparison of the cost efficiency level among developed European countries, U.S and Japan. Only three articles investigate the performance of banking firms into the emerging financial markets and none for Asian countries and regions. This gives us the strong motivation to investigate into these Asian countries and regions to fill the gap in the literature. The fundamental reason for this gap can be attributed to the lack of essential satisfactory quality of data and other issues. However, after experiencing the deep economic and financial reform in the last two decades, emerging Asian countries and regions such as China, Hong Kong SAR and Korea change dramatically and start to influence the whole world using their own economic powers. It is also possible for us to obtain the comparable banking data from the worldwide database Bankscope, central bank websites and annual financial reports of individual bank. With good quality data and by using the advanced panel data approaches, we should be able to conduct our investigation to measure the efficiency level of Chinese banks and compare with other Asian countries and regions.

2.2 Utilized measurement technology

In order to compare the efficiency level in an international basis, the existing cross-country studies coincidently build up a common frontier (either production or cost or profit) as a benchmark. Technical efficiency (cost or profit efficiency) then is calculated or estimated by using either the non-parametric approach such as DEA or parametric approaches such as SFA and DFA. In our survey, five studies utilize the DEA to measure the efficiency score. Nine studies use SFA while two adopt DFA. DEA is a linear programming technique where the observed banking firms are used to form the efficient frontier as the piecewise linear combinations that connect the best practice observations, yielding the convex production possibilities set. Those banks that lie on the frontier are the most efficient. On the other hand, banks that do not lie on that surface can be considered as inefficient and an individual inefficiency score will be calculated for each one of them. Since the DEA suffers a key drawback of not allowing the random error, SFA is preferred. We will discuss this methodology in detail in the methodology session.

2.3 Output and input specification

As in any efficiency studies, before a model of production and cost function for the banking firms can be developed, the input and outputs of the banking firm should be clearly defined. However, no general consensus exists as to the precise definition of what a bank produces or how one can measure this product since financial firms provide services rather than readily identifiable physical products and it is not clear how to measure service outputs. Therefore, based on the role of deposits, output and input specification varies between studies. The following four approaches are the most widely used specifications in the literature, which are intermediation approach, production approach, dual approach and value-added approach (In our survey, six studies adopt the intermediation approach; two adopt the production approach and dual approach respectively and four apply the value-added approach). The intermediation approach views banks as institutions that collect deposits and then allocate funds in loans and other assets; deposits are included among the inputs and the corresponding interests of funds are in the total costs. The production approach takes a different view to define the bank activity as production of services. Thus deposits are counted as output and interests paid on the deposits are not included in the total costs. The dual approach is first introduced by Berger and Humphrey (1997). Since "*Neither of these two approaches is perfect because neither fully captures the dual roles of financial institutions as (i) providing transactions/document processing services and (ii) being financial intermediaries that transfer funds from the savers to investors.*", dual approach attempts to capture the dual roles of deposits, as input and output. The value-added approach identifies any balance sheet item as output if it absorbs a relevant share of capital and labour, otherwise it is considered as an input or non relevant output; according to this approach deposits are considered as an output since they imply the creation of value added.

2.4 Cross-country heterogeneous factors

As argued by Berger and Humphrey (1997), *"cross-country comparisons are difficult to interpret because the regulatory and economic environments faced by financial institutions are likely to differ importantly across nations…Such cross-country differences were not specified when a 'common' frontier was being estimated and this may affect the cross-country results."* Nine studies in our survey share the assumption that banks of those countries in comparison provide banking services under the same production process and conditions. Therefore, the observed inefficiency can be attributed to the poor managerial performance. However, as known to all, countries may differ not only geographically, but also from macro economic powers and financial regulatory requirement. Differences of managerial abilities within the banks may not be the only reason to explain the observed difference of banking efficiency score. Therefore, in setting up the common frontier as benchmark, the cross-country heterogeneous factors cannot be excluded. In contrast, five recent cross-country studies include these heterogeneous factors into the model by introducing some sets of environmental variables to reflect the various differences among countries. From their empirical results, it is clear that the efficiency score is higher when cross-country heterogeneity is considered, indicating that part of the inefficiency can be explained by these heterogeneous factors. Therefore, neglecting these factors may cause underestimated efficiency score.

3. Methodology

3.1 Panel Data Stochastic Frontier Approach

First proposed by Aigner et al (1977) and Meesuen and van den Broeck (1977), stochastic frontier approach (SFA) has been widely used in the efficiency literature. These models allow for technical inefficiency, but they also acknowledge the fact that random shocks outside the control of producers can affect the output of the producer. The great contribution of the models is that by forming a composed error term, they separate the idiosyncratic errors from the technical inefficiency. Therefore, the technical inefficiency would not be contaminated by the random errors that shouldn't be considered as inefficiency.

Rather than using a cross-sectional stochastic frontier models that has been widely adopted in the cross-country studies, we prefer the panel data framework due to the limitations of the cross-sectional models. First, the strong distributional assumption in cross-section framework can be relaxed by using panel data estimation technique. Second, not all the panel data estimation techniques require the independences of the technical inefficiency error component from the regressors. It may be incorrect to assume that technical inefficiency term to be unrelated to the regressors since if a firm knows its levels of technical inefficiency; it certainly will affect its input choices. Finally, since adding more observations on each producer generates information not provided by adding more producers to a cross section, the technical efficiency of each producer in the sample can be measured consistently.

Panel data stochastic frontier approaches were first proposed in Schmidt and Sickles (1984) (See Kumbhakar and Lovell, 2000 for a detailed survey on panel data methodology). General panel data cost frontier model[1] can be written as follows

$$\ln C_{it} = \ln C\left(y_{it}, w_{it}; \boldsymbol{\beta}, \boldsymbol{\delta}\right) + v_{it} + u_{it}$$
$$= \alpha_0 + \boldsymbol{\beta}' \ln y_{it} + \boldsymbol{\delta}' \ln w_{it} + v_{it} + u_{it}$$

where C_{it} stands for total costs and C(.) is the specified cost function. y_{it} and w_{it} represents outputs and input prices respectively. $u_{it} \geq 0$ represents the cost inefficiency while $v_{it} \sim iid\left(0, \sigma_v^2\right)$ stands for the random errors that are beyond the control of firms.

If cost efficiency is time-invariant, fixed-effects (FE) and random-effects (RE) model can be adopted and the general panel data models will be modified as

$$\ln C_{it} = \alpha_0 + \boldsymbol{\beta}' \ln y_{it} + \boldsymbol{\delta}' \ln w_{it} + v_{it} + u_i$$

The FE model assumes that v_{it} is $iid\left(0, \sigma_v^2\right)$ and uncorrelated with the regressors. No distributional assumption is made on u_i and we allow it to be correlated with the regressors or v_{it}. Since u_i is treated as fixed, it becomes the producer specific intercept parameters to be estimated with β_{it} and δ_{it} by using the least squares with dummy variables, LSDV for short. The model will be modified as

$$\ln C_{it} = \alpha_{0i} + \boldsymbol{\beta}' \ln y_{it} + \boldsymbol{\delta}' \ln w_{it} + v_{it}$$

where $\alpha_{oi} = \alpha_0 + u_i$. By using the transformation $\hat{\alpha}_0 = \min\left(\hat{\alpha}_{0i}\right)$ and $\hat{u}_i = \hat{\alpha}_{0i} - \hat{\alpha}_0$, cost efficiency can be obtained by $CE_i = \exp\left(-\hat{u}_i\right)$. However, FE model suffers a potential defect that the inefficiency term u_i will capture all the time-invariant effects that vary across firms, including the time-invariant inefficiency and the other time-invariant factors such as the regulatory environment. Therefore, the cost inefficiency

[1] For simplicity, Cobb-Douglas functional form will be used in all the introduction of panel data models.

might be overestimated. Schmidt and Sickles (1984) argued that this problem could be fixed with RE model since the assumption of the cost inefficiency term to be randomly distributed with constant mean and variance and not correlated with any regressors and v_{it} allowed some time-invariant regressors in the model. If so, the RE model can be written as

$$\begin{aligned}\ln C_{it} &= C(y_{it}, w_{it}; \boldsymbol{\beta}, \boldsymbol{\delta}) \\ &= [\alpha_0 + E(u_i)] + \boldsymbol{\beta}'\ln y_{it} + \boldsymbol{\delta}'\ln w_{it} + v_{it} + [u_i - E(u_i)] \\ &= \alpha_0^* + \boldsymbol{\beta}'\ln y_{it} + \boldsymbol{\delta}'\ln w_{it} + v_{it} + u_i^*\end{aligned}$$

and generalized least squares can be used to estimate the cost efficiency. Pitt and Lee (1981) extends this RE model by adding further distributional assumption on v_{it} and u_i, which allows $v_{it} \sim N(0, \sigma_v^2)$ and $u_i \sim N^+(0, \sigma_u^2)$. Then maximum likelihood estimation (MLE) can be used to estimate the cost efficiency, and MLE is consistent and asymptotically efficient.

Another school of thoughts believe that within a long panel, the assumption of time-invariant cost inefficiency will be too strong especially when the open environment is competitive. The longer is the panel the more desirable it is to relax the time-invariant assumption. In the literature, a number of studies have adopted the Battese and Coelli (1992, 1995) model, where the authors try to relax the assumption of time-invariant inefficiency by introducing the additional term $u_{it} = \exp(-\gamma(t-T)) \cdot u_i$ into Pitt and Lee (1984) RE model. The cost inefficiency is said to decrease in an increasing rate if $\gamma > 0$ an increase in an increasing rate if $\gamma < 0$.

However, as argued in Greene (2004, 2005a, 2005b), the above conventional panel data models have one limitation of not including the time-invariant heterogeneities in those models. And if these time-invariant heterogeneities do exist but are not included, all these heterogeneities will be pushed into the intercept term α_0 and finally into the inefficiency term u_i. Correspondingly, we will have an overestimated cost inefficiency score. These limitations are relaxed by introducing so called the 'true' fixed-effect model and 'true' random-effects model. In his 'true' FE model, firm specific constant terms are introduced in the stochastic frontier models, written in the cost frontier version, $\ln C_{it} = \alpha_i + \boldsymbol{\beta}'\ln y_{it} + \boldsymbol{\delta}'\ln w_{it} + v_{it} + u_{it}$, where α_i incorporates all the time-invariant firm specific heterogeneities and the regressors, random errors and inefficiency terms are mutually uncorrelated. But we have to sacrifice the freedom of no distributional assumption on the random errors and inefficiency term as they have to follow the normal and half-normal distribution respectively, but u_{it} is not restricted to be time-invariant. Then the MLE can be used to estimate the inefficiency. The 'true' RE model uses the random constant term to embody the time-invariant firm specific heterogeneities in the cost function, written as:

$$\ln C_{it} = (\alpha + w_i) + \boldsymbol{\beta}'\ln y_{it} + \boldsymbol{\delta}'\ln w_{it} + v_{it} + u_{it}.$$

However, these 'true' SFA models may overcompensate for the heterogeneity since the inefficiency can be time-invariant to some extent in financial systems where performance related incentives are weak or absent. If there is persistent inefficiency, it is completely absorbed in the firm specific constant term which is also capturing any time-invariant heterogeneity. Consequently, as the conventional fixed-effects model might overestimate the inefficiency, the 'true' SFA models might underestimate it.

Therefore, for a cross-country banking efficiency comparison, with the availability of the information of the cross-country heterogeneous factors in geographic, economic and regulatory perspectives, we should measure the time-invariant effects as both time-invariant heterogeneities and the time-invariant inefficiency. Obviously, the conventional FE model cannot include cross-country heterogeneities so only conventional RE model can be used for this purpose. In our paper, we will first compare the empirical results of using conventional panel data stochastic frontier models with Greene's 'true' stochastic frontier models. Then we will include the cross-country heterogeneous factors in the model to measure whether it can explain part of the inefficiency.

3.2 Model specification

In our study, the total costs of bank i $C_{it}(i = 1...I)$, observed for t (t=1…T) times, are given as a function of three outputs $y_{jit}\left(j=1...3\right)$, three input prices $w_{mit}\left(m=1...3\right)$ and the equity capital E_{it}. Equity capital is included since it may influence the probability of banks' failure and so interest costs. Also, a bank's capital level will directly affect costs by providing an alternative to deposits as a funding source of loans as a substitute for deposits or other funding sources.Thus the translog cost function for a given bank i at time t can be written as follows:

$$
\begin{aligned}
\ln\frac{C_{it}}{w_3} &= \alpha+\sum_{j=1}^{3}\beta_j \ln y_{jit}+\sum_{m=1}^{2}\delta_m \ln\frac{w_{mit}}{w_3}+\xi_i \ln E_{it} \\
&+\frac{1}{2}\sum_{j=1}^{3}\sum_{k=1}^{3}\beta_{jk}\ln y_{jit}\ln y_{kit}+\frac{1}{2}\sum_{m=1}^{2}\sum_{n=1}^{2}\delta_{mn}\ln\frac{w_{mit}}{w_3}\ln\frac{w_{nit}}{w_3}+\sum_{j=1}^{3}\sum_{m=1}^{2}\gamma_{jm}\ln y_{jit}\ln\frac{w_{mit}}{w_3} \\
&+v_{it}+u_{it}
\end{aligned}
$$

To ensure the symmetry, the following restriction is imposed:

$\beta_{jk}=\beta_{kj}, j,k=1...3$

$\delta_{mn}=\delta_{nm}, m,n=1...2$

$\sum_{j=1}^{4}\gamma_{jm}=0, m=1...2$

In addition, total cost and input price term are normalized by the third input price, w3, to imposing the linear homogeneity restriction in the model.

For conventional fixed-effects model, cost inefficiency can be obtained by estimating and transforming the intercept parameters as discussed in the last section. For conventional random-effects and 'true' SFA models, parameters can be estimated by MLE and then cost efficiency score can be obtained by using Jondrow et al (1982)'s $E\left(u_{it}\mid\varepsilon_{it}\right)$.

4. Data

Ten Asian countries and regions are involved in the study, which are China, Hong Kong SAR, India, Indonesia, Malaysia, Philippines, Singapore, South Korea, Taiwan Province of China and Thailand covering the period from 1998 to 2005. Annual data is collected from the balance sheet and income account of individual bank from the Bankscope database. Since all the data are collected on the nominal value in own currency from Bankscope, in order to allow the cross-country comparison, all the data are then converted to US dollar using Purchasing Power Parity exchange rate (PPP) with inflation adjusted (see Table 2).

Insert Table 2 here

In the sample data set, only commercial banks are considered and the unconsolidated financial reports are used. For those missing data that not reported in Bankscope, we check and collect them from the alternative data sources, for instance, we look into the annual report of individual bank, the statistic yearbook of individual country or region, the statistic department of individual country or region and the labor department of individual country or region, etc. To maintain the consistency with the data from Bankscope, we carefully check the data from the alternative source to make sure it works. Due to the missing data in different banks in different countries and districts from different years, we end up with an unbalanced panel data set containing 285 banks (48 Chinese banks, 22 banks in Hong Kong SAR, 56 Indian banks, 35 Indonesian banks, 22 Malaysian banks, 24 Philippine banks, 5 Singaporean banks, 16 banks in South Korea, 41 banks in Taiwan Province of China and 16 banks in Thailand) with the total number of 1975 observations.

Table 3 summarized the dependent and independent variables in this study with the average value of these variables being reported. In next section, we will discuss each variable in detail, like the definition and the way it is being processed.

Insert Table 3 here

The definition of total costs is determined as the sum of the interest expense, the personnel expenses and other expenses.

Regarding the definition of the output and input price specification, an intermediation approach (see Sealey and Lindley, 1977) is adopted. Under this treatment, the outputs are specified as total loans (Y1), which include short term loans, trade bills and bills discounted, medium and long term loans, other loans, excludes the loan loss reserves; other earning assets (Y2) such as short term and long term investment, deposits with central bank and other banks; non-interest income (Y3) comes from net fee and commission and other operating income.

The input price specification lies on the following three variables. First is price of funding/deposit (W1). It can be calculated by the ratio of interest expenses to total deposits. The second variable is the price of labor (W2). It can be calculated by the ratio of personnel expenses to number of employees. Collecting this variable is the hardest part of the data processing since we have to collect both the personnel expenses and number of employees to calculate this figure out. However, not all the banks' reports collected from Bankscope provide the data for their personnel expenses or number of employees and sometimes both of them are missing in the reports. This perhaps explains partly why limited cost banking efficiency study in Asian countries and regions exists in the literature. Therefore, in this context, this study suggests an alternative approach in the area. The ways to handle out this problem rely on some reasonable and acceptable assumptions. For those banks missing the data for number of employees (i.e. banks in Hong Kong SAR), we check the website of the central bank, the statistic department, annual reports each year, and other possible sources for this information. Probably, we may have the data for some years but not all the periods, therefore, we have to assume that the growth rate of the number of employees is the same as the growth rate of total assets for a given bank. Based on this widely accepted assumption (see Altunbas, et al, 2001, Vander Vannet, 2002 and Fu and Heffernan, 2005), we can get the data for the other year and calculated the price of labor. For those banks missing the data for personnel expenses, we have to use the proxy as the price of labor. If collectable, average wage rate in finance sector can be served as a good proxy for price of labor. Then we can calculate the personnel expenses. If average wage rate is only available for a few years, we may follow the assumption that the growth rate of wages is the same as the growth rate of total assets for finance sector. For those banks lacking of both of the data, we have to drop it out of the sample since normally, we cannot estimate with missing variable. The final one is the price of fixed assets (W3), which is measured by the ratio of other operating expenses to the fixed assets. Here we are interpreting this operating expenses as capital maintenance.

Another important set of variables are the cross-country environmental variables. As widely suggested in the current literature, three categories of environmental variables are taken into account: (i) those that describe the main macroeconomic conditions, which determine the banking product demand characteristics, (ii) variables that describe the structure and regulation of the banking industry and (iii) accessibility of the banking services. These three categories of environmental variables are described in Table 4.

Insert Table 4 here

The first group is termed as “macro-economic conditions” and includes a measure of population density, GDP, GDP per capita, Inflation, unemployment ratio and density of demand. These variables simply represent the main macro conditions under which banks are providing their services. The population density is termed as population per square kilometres. Intuitively, banks may face a high costs when providing services in the area with a low population density and we can expect the potential low cost efficiency level. GDP is the main indicator of a country’s macro-economic power. GDP per capita (ratio of GDP over inhabitants) reflects the issue that countries with high per capita income may have a banking system that operates in a mature environment which can set a more competitive interest rate and profit margin. Thus the expectation for GDP per capita can be either positive, which suggests that the more developed economy is, the higher costs banks incur since banks are operating in a powerful and blooming condition, it can offer competitive interest rates and at the meanwhile the labor expenses may also be higher than before, or negative since the more developed economy, the higher possibility that their banking system may experience technological improvement that may save banks huge amount of money, or individual customer may involve in a wide range of banking services which may save the cost of banks to search new customers and expand their services. Inflation, measured as average CPI (Consumer Price Index) for each year with the base year 2000, is another important economic factor that may also influence the macro-economic condition and financial system. The higher inflation may cause the depreciation of the national currency and the increasing of the price for the products. Then in order to fulfil the basic living standard, individuals will reduce their savings in the bank and producers may also have the same response for the demand of production. In the other end, number of borrowers will increase due to the decreasing of cost of borrowing. Therefore, to fill the gap, banks have to increase their interest rates and look for the alternative funding source, which may increase the costs for banks since deposits from individuals and companies are the cheapest way of getting funding. Other ways such as increasing the shares in the market or increase holding of equity capital are far more expensive and will increase the total costs for banks. So we may expect the higher costs with the higher inflation. The unemployment rate is also very important since higher unemployment rate may reflect the depression of the whole economy and the depression will spread to the financial sector. Therefore, it may incur the higher costs of banks' business and operation. The final variable in this group is the density of demand, measured by deposits per square kilometres. It is a relevant feature in determining the efficiency. Banks operating in markets with a lower density of demand incur higher expenses.

Five components in the second category are used to reflect the banking and financial structure of those countries. The first one is a measure of bank concentration, termed as the assets of three largest banks as a share of assets of all commercial banks. Higher concentration may be associated with either higher costs or lower costs. As argued by Dietsch and Lozano-Vivas (2000), if higher concentration comes from the market power, costs will go with the same direction. However, cost may go with the opposite direction if higher concentration is caused by the superior management or superb efficiency of the production processes. The second variable being used is the net interest margin. It is calculated as the accounting value of bank's net interest revenue as a share of its total earning assets (See IMF interpretation). It captures the difference between different banking industries in terms of their ability to covert deposits to loans. The more efficient is the bank in converting deposits to loans, the higher is his net revenue margin and the lower is the banking system costs. The third one is bank overhead ratio, termed as the accounting value of a bank's overhead costs as a share of its total assets. If observing higher overhead ratio, the banking industry may face a higher costs and we can expect this higher system costs spread to individual banking firm in the system. Next variable is the capital ratio, measured as the ratio of equity capital to total assets. The higher capital ratio, the lower insolvency risk of the bank and lower cost imposed. The last variable is intermediation ratio, which capture the ability of banks to convert its deposits to loans. The higher ability of that may save banks' cost.

The third category only includes one component, which is the density of branches. It is measured by the ratio of the number of branches per square kilometres. A lower branch density level may leads to lower banking costs. It is also a good indicator of the potential overcapacity in the branch network and may also measure the level of competition in the banking market.

Insert Table 5 here

Table 5 reports the average value of these environmental variables over 1998-2005 periods for these ten Asian countries. These arithmetic means suggests the large difference in the main conditions of banking activities across countries. These environmental variables are measured in aggregate for banking system of each country and region and therefore they vary through time but not across banks within each country and region, but they do vary across countries and regions. Therefore they pick up inter-country heterogeneity and we may expect a biased cost efficiency score when using a common cost frontier or same production process for different countries and regions. In our study, to show the importance of these environmental variables, we will compare the empirical results from excluding and including the environmental variables in the cost function.

5. Empirical Results[1]

5.1 Primary results without incorporating the cross-country heterogeneity

As expected, when not accounting for the impact of cross country heterogeneity, lower efficiency scores observed from conventional panel data models than from Greene's true RE model (see Table 6).

Insert Table 6 here

The estimated coefficients for the parameters of the conventional panel data models are quite similar although based on different model assumption and estimation technology. However, the cost efficiency scores differ a bit showing the average level of around 29% from the FE model, which is 9% less than that from the RE model for the whole sample data[2]. When collecting the cost efficiency score in country basis, we still observe the similar phenomenon. However, from Figure 1 and the correlation matrix Table 7, we can see that they provide the similar scene. This result coincides

[1] All the empirical results are estimated using the software Limdep.

[2] Hausman test favours the FE than RE. However, we can still justify the use of the RE model. The Hausman test is based on the conventional panel data model and concentrates on whether the individual-specific effects α_i is random- or fixed-effects. But in efficiency study, what we are really interested in is whether the inefficiency is random or fixed effects. The Hausman test would simply reject the former based on the existence of correlatedness between the individual-specific effects and the regressors, but not necessarily the inefficiency itself. Since the inefficiency term in the fixed-effects model might capture all the time invariant heterogeneity, there is a possibility of the correlatedness between those heterogeneity and the regressors but ultimately impose this correlatedness to the inefficiency term, which actually is not correlated with the regressors. This complication is the special feature in the stochastic frontier models.

with our expectation that the without incorporating the cross-country heterogeneities, conventional panel data models perform very poor and the cost efficiency are underestimated.

Insert Figure 1 here

Insert Table 7 here

When comparing the conventional FE model with the 'true' RE model[1], we observe a large gap of efficiency level between the two. 'True' RE model shows around three times the efficiency score than the conventional FE model. This result is expected since the set up of the 'true' SFA model enables us to move some of the time-invariant heterogeneity out of the inefficiency term, but such high efficiency scores, which are nearly even distributed between countries, are not expected and unreliable. Practically, the above result suggests that the banking systems in these Asian countries are operating in a very high efficiency level across the sample year. However, regarding to impact of the Asian financial crisis during 1997 and 1998, we expect to see a lower cost efficiency score at least in year 1998 to 2000 for countries like Indonesia, Malaysia, and Philippines, which suffer a destructive blow in their financial system. Theoretically, as argued in the methodology section, the 'true' SFA models overcompensate for the heterogeneities and therefore, the cost efficiency might be overestimated. Unfortunately, this is the inherent feature in the modeling problem since $\alpha_i + v_{it} + u_{it}$ contains both country specific heterogeneity and inefficiency, and both may have time-invariant and time-varying elements.

To summarize, conventional FE model assumes all the time-invariant effects to be time-invariant technical inefficiency while true FE and RE model assumes all the time-invariant effects to be time-invariant heterogeneity. Therefore, constructing a panel data model that can allow both cross-country heterogeneity and time-invariant inefficiency is of our interest. By incorporating the cross-country heterogeneous factors into the conventional RE models (i.e. Pitt and Lee model or Battese and Coelli model), we can build up the correct common frontier with the preferred technology.

5.2 Results with incorporating the cross-country heterogeneity

[1] 'True' FE model is not stated here since although we observe the expected efficiency score, the coefficients for lny3 and w2 are not significant that suggest the model is not robust. So we only report results from the 'true' RE model.

Initially, twelve cross-country environmental variables are collected and specified into three categories (described and summarized in Table 4 and Table 5). However, during the model regression, four of them (GDP, Density of Demand, Overheads ratios, Density of Branches) are found insignificant and therefore, we dropped them from the sample. Table 8 reports the estimated coefficients for the parameters and the corresponding cost efficiency score are presented in Table 9.

Insert Table 8 here

Insert Table 9 here

Insert Figure 2 here

Insert Table 10 here

As evidenced from Figure 2 and correlation matrix (Table 10), the correlation of these models is still very high, which means they more or less describe the similar scene here. However, Battese and Coelli model does suggest that the inefficiency is increasing over time since estimated η is significantly negative. Therefore, Battese and Coelli model is preferred. As seen from Table 10, estimated λ s , as a ratio of inefficiency standard deviation to standard deviation of idiosyncratic error, for both models are less than λ s in those models when cross-country heterogeneity is not taken into account (λ is 9.903 in PL model and 10.211 in BC model not controlling for the heterogeneity). Therefore, coincide with the smaller λ , the average cost efficiency in the whole sample is higher than the ones we have from not controlling heterogeneity, which suggested that inefficiency terms in conventional model where cross-country heterogeneity is not controlled does absorb some of the heterogeneity and the inefficiency score is overestimated. After excluding some of those heterogeneous factors from the inefficiency term and including them in the model setup, we observe a higher level of cost efficiency by increasing around 15%.

With regard to country specific cost efficiency score estimated by Pitt and Lee model, when cross-country heterogeneity is not controlled, Malaysia and Singapore are the most efficient. However, after incorporating cross-country heterogeneity, the respective efficiency score increase dramatically. India becomes the most efficient with efficiency score increased by 25%. Singapore and Malaysia follow up by increasing 7% and 2%. Indonesia, China and Philippines increase their efficiency level sharply by 11%, 17% and 15% respectively. The efficiency score for Hong Kong SAR, South Korea, Taiwan Province of China and Thailand also rise slightly by 2%, 5%, 2% and 7%. The results of Battese and Coelli model present the similar trend of change in efficiency score for individual country and region. These results indicate that the country specific environmental variables are important in explaining the efficiency level and should not be excluded.

From the empirical results, we find that China only ranks fourth in ten Asian countries and regions with India leading us by 20%. The relatively low cost efficiency level can be explained from the short history of Chinese economic and financial reform. In the two decades' economic and financial reform, China has become the powerful economy in the world. But this powerful phenomenon is mainly reflected in the manufacturing industry, benefited from the low price of labor. The financial sector is still under-developed and the majority of banks' income comes from the traditional financial intermediation services. However, by deeper financial reforms such as privatization, deregulation, development of off-balance sheet business, we may expect that Chinese banks could become more competitive and perform more efficiently.

5.3 Impact of cross-country heterogeneous factors

Including the cross-country environmental variables help us correctly construct the common frontier and exclude some part of the time invariant heterogeneity out of the inefficiency term. Besides these huge impacts, we are also interested in whether the influence of these environmental variables is in line of our expectation. This is reported in Table 11.

Insert Table 11 here

First, consider the role of main economic indicators. Contrary to our expectations, the coefficient of population density variables has a positive sign. Higher density contributes to an increase in banking costs, instead of the expected decrease in costs. One reason can be found in the characteristics of banking competition. In higher density area, banks may force to open more branches to compete for customers. Other promotion and strategic operations may also increase the level of banks' cost. The expectation for GDP per capita can be either positive or negative. Coinciding with our expectations, we observe negative sign, suggesting that banks benefit more from the technological change and well diversification and expansion of their business, which substantially reduce their operational expenses. The positive sign of inflation is also in line with our expectation as the higher inflation, the higher costs it may incur since the inflation may increase the input prices involved in the banking production process. For instance, employees may demand higher payment and savers may ask for higher deposits rate, etc. Last candidate in this group is unemployment ratio, the other main indicator for the macro-economic environment. High unemployment rate reflects poor economic development. Therefore, banks in these countries may seek various routes to maintain the current business level and reduce the potential risks in their loans and other services. At the meanwhile, it may also cut the costs sharply to balance the income statement. Therefore, our expectation of the influence of unemployment is negative, which is also reflected in our results.

The second group of environmental variables is those reflect the banking structure and regulatory conditions. The first is banking concentration. As discussed before, higher concentration may associate with either higher or lower costs. If higher concentration is a result of market power, we may expect costs go in the same direction. However, if higher concentration results from the superior management, we may expect a negative sign. Our empirical results show the negative sign in favor of the superior management. The second indicator is net interest margin, which is the difference between the interest rate of loan and deposits. The higher interest margin, the more profitable is the bank and higher ability to convert deposits to loans. Thus lower costs from banks, which is observed in the empirical results. The negative sign of capital ratio is also expected since lower capital ratio indicates higher insolvency risk of banks therefore banks may have a higher operational cost in running the business. The last environmental variable is the intermediation ratio. It captures the ability of banks to convert the deposits into loans. The higher intermediation ratio indicates the higher ability of repay the interests to the depositors and therefore may lower the banks' costs. As expected, we observe the negative sign.

6. Conclusions and directions for future research

To fill the gap of the existing literature of international comparison of the banking efficiency and productivity analysis, this paper conducts a cross-country study to measure and compare the cost efficiency score for 285 commercial banks among ten Asian countries and regions. Unlike the previous cross-country studies, our paper uses the panel data stochastic frontier approach as compared with the cross-sectional framework, panel data approaches can relax the strict distributional assumption of the inefficiency term and generate the consistent inefficiency estimation.

An important feature of cross-country studies is that countries differ from each other in many aspects such as geography, culture, macro-economic condition and financial regulatory requirement, etc. Difference of inefficiency level may not only attribute to the managerial ability of the banks but can be partly explained by the different characteristics of the country. Thus the country specific environmental variables should not be excluded from the common cost frontier if attainable. Otherwise, the estimated efficiency level would be underestimated. This is proved in our empirical results. We compare the cost efficiency scores estimated from the panel data SFA models with or without incorporating the cross-country heterogeneous factors. We found that when heterogeneity is considered, the cost efficiency score is higher than when it is not included.

Moreover, India is found to be the most efficient among these ten Asian countries and regions while China only ranks fourth as 20% less efficient, which indicate that the Chinese banking industry is not so competitive against our neighbors and we have to deepen the financial reform and improve the managerial ability.

In the future, we would like to extend this study in the following three dimensions. First, from the empirical results (see Table 8), we find that at the sample mean, there are economies of scale for these Asian banks but we have not yet tested whether this result is significant or not. Second, we have to test whether our translog functional form satisfies the properties of the cost function. Although the monotonicity condition is satisfied, we have not yet tested the concavity condition. Finally, we intend to use the more flexible functional form, the Fourier flexible cost function to estimate the cost efficiency and to test whether there are scale bias in the sample.

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Table 1: Survey table of cross-country banking efficiency studies

No.	Studies	Key features	Efficiency score	General conclusion
1	Allen and Rai (1996)	- Cost and profit efficiency - 15 EU countries and US from 1988-92 - SFA and DFA - Intermediation approach	Mean cost efficiency: 0.78/0.85 (Large/small banks)	Large banks was found to be the most inefficient as well as diseconomies of scale.
2	Altunbas, et al (2001)	- Cost efficiency - 15 EU countries from 1989-97 - SFA - Intermediation approach	Mean cost efficiency: 0.75 to 0.8 across different sizes	Efficiency score vary across country, bank sizes and over time, which suggests that great cost savings can be achieved by improving managerial performance.
3	Berg et al (1993)	- Technical efficiency - 3 Nordic Countries - DEA - Value-added approach	Mean technical efficiency: VRS: Fin: 0.53, Nor: 0.58, Sw: 0.78 CRS: Fin: 05, Nor: 0.41, Sw: 0.69	By setting up the common frontier, Sweden is found to be the most efficient country among three.
4	Casu and Girardone (2004)	- Cost and profit efficiency - 5 EU countries from 1993-97 - DEA and SFA - Intermediation approach - Country-specific environmental variables	Mean cost efficiency: 0.855 Mean Profit efficiency: 0.54 in 1993 to 0.9 in 1997	Efficiency level is not converged despite harmonization of EU. Country factors appear to be important in explaining inefficiency. Profit efficiency shows a sharp growth over time.
5	Carvallo and Kasman (2005)	- Cost efficiency - 16 Latin American countries from 1995-99 - SFA - Dual approach	Mean cost efficiency: 0.822	The efficiency level varies across countries dramatically while the largest economy appears to be the most efficient.
6	Dietsch and Lozano-Vivas (2000)	- Cost efficiency - Spain and France from 1988-92 - DFA - Value-added approach	Mean cost efficiency: Without environmental variables Fr: 0.58, Sp: 0.09	Cross-country heterogeneous factors have an important role on explaining part of the inefficiency. Without considering them, the efficiency estimates would be biased.

		- Country-specific environmental variables	With environmental variables Fr:0.89, Sp: 0.75	
7	Fries and Taci (2004)	- Cost efficiency - 15 transition countries from 1994-01 - SFA and DFA - Production approach - Country-specific environmental variables	Mean cost efficiency: Without environmental variables 0.63 With environmental variables 0.71	Privatization can effectively increase the operating efficiency based on the evidence that private banks are more efficient than state-owned banks. Foreign ownership do help improve the managerial ability.
8	Kasman and Yildirim (2006)	- Cost and profit efficiency - 8 central and eastern European countries from 1995-02 - SFA - Dual approach - Country-specific environmental variables	Mean cost efficiency: 0.793 Mean profit efficiency: 0.633	Cost and profit efficiency spreads substantially among different countries. Foreign banks perform more efficient than domestic banks.
9	Lozano-Vivas et al (2002)	- Cost efficiency - 10 EU countries in 1993 - DEA - Value-added approach - Country-specific environmental variables	Mean cost efficiency: Without/with environmental var. Bel: 0.42/0.79, Den: 0.2/0.75, Fr: 0.24/0.41, Ger: 0.27/0.58, It: 0.25/0.33, Lux: 0.49/0.62, Net: 0.37/0.52, Por: 0.16/0.8, Sp: 0.19/0.82, UK: 0.22/0.59	Country-specific environmental variables exercise a strong influence over the behaviour of each country's banking industry
10	Maggi and Rossi (2003)	- Cost efficiency - 15 EU countries and US from 1995-98 - DFA - Production and value-added approach	Mean cost efficiency: EU: 0.64, US: 0.62	Fourier flexible functional form fit the data better than the translog functional form.
11	Maudos et al (2002)	- Cost and profit efficiency - 10 EU countries from 1993-96 - SFA and DFA	Mean cost efficiency: 0.83 (DFA), 0.77 (FE), 0.84 (RE)	Profit efficiency is lower than cost efficiency implying that the most important inefficiency on the revenue side.

		- Intermediation approach	Mean profit efficiency: 0.45 (DFA), 0.22 (FE), 0.52 (RE)	
12	Pastor et al (1997)	- Technical efficiency - 8 EU countries for the year 1992 - DEA - Value-added approach	Mean technical efficiency: 0.86	Technical efficiency varies among countries.
13	Vander Vennet (2002)	- Cost and profit efficiency - 17 EU countries from 1995-96 - SFA - Intermediation approach	Mean cost efficiency: Universal: 0.8, specialized: 0.7	Universal banks perform more efficiently than separated banks.
14	Weill (2004)	- Cost efficiency - 5 EU countries from 1992-98 - DEA, SFA, DFA - Intermediation approach	Mean cost efficiency: Fr: 0.71, Ger: 0.83, It: 0.84, Sp: 0.78, Sw: 0.66	Lack of robustness between approaches, even if there are some similarity in particular between parametric approaches. Mixed evidences of the relationship between bank size and efficiency were found.

Table 2: PPP exchange rate for the Asian countries (National currency per current international dollar)

Country	1998	1999	2000	2001	2002	2003	2004	2005
China	2.011	1.966	1.964	1.957	1.935	1.944	2.021	2.047
Hong Kong SAR	8.666	8.051	7.436	7.129	6.763	6.202	5.811	5.63
India	8.034	8.256	8.386	8.488	8.606	8.778	8.894	9.064
Indonesia	1,827.49	2,056.52	2,184.84	2,438.68	2,538.15	2,621.65	2,766.69	3,084.97
Malaysia	1.622	1.6	1.641	1.557	1.587	1.609	1.662	1.687
Philippines	9.739	10.371	10.794	11.214	11.518	11.704	12.065	12.442
Singapore	1.712	1.598	1.623	1.554	1.512	1.467	1.481	1.446
South Korea	769.438	757.709	747.013	755.32	763.305	767.765	766.653	744.381
Taiwan Province of China	21.392	20.81	20.037	19.663	19.163	18.362	17.57	16.957
Thailand	13.354	12.631	12.529	12.488	12.374	12.29	12.344	12.527

Source: International Monetary Fund, World Economic Outlook Database, April 2007

Table 3: Average values of the banking costs, outputs and input prices for 10 Asian countries (mil US$)

	China	Hong Kong SAR	India	Indonesia	Malaysia	Philippines	Singapore	South Korea	Taiwan Province of China	Thailand
Total Costs	7662.7	690.563	2296.1	881.251	548.458	594.879	503.725	2774.84	996.147	1339.73
Total Assets	238171	22325.5	30406.7	7737.81	13816.4	8413.31	19466.7	53162.3	24968.4	31593.3
Equity Capital	9681.55	1683.06	1580.31	411.784	1150.26	1014.4	2271.85	2721.5	1839.51	2197.44
Y1: Loans	136424	9870.66	13245.9	2473.19	8286.58	3704.72	9244.91	33975.7	16029.9	19246.6
Y2: Other earning assets	86388.9	10088.3	13566.2	4258.64	4897.61	3227.73	8542.01	14203.3	6769.23	9608.98
Y3: Deposits	531.44	201.279	475.907	113.787	137.808	158.198	161.533	349.832	130.816	268.168
Y4: Non-interest Income	215744	18757.6	26021.8	6821.29	11421.9	6830.82	16243.7	42683.1	21678.9	27648.3
W1:Price of funds	0.0232948	0.0573383	0.0671051	0.089682	0.035506	0.056823	0.0392403	0.0504226	0.032153	0.032591
W2:Price of labor	0.0296837	0.0337028	0.0361682	0.046434	0.006304	0.0450622	0.110132	0.0969563	0.051745	0.048543
W3:Price of fixed assets	0.797542	3.96974	0.850216	2.8942	2.05444	1.46147	6.29587	0.471156	0.717093	0.39129
Number of Obs.	285	167	384	232	153	175	38	118	313	110
Total Obs.	1975									

Source: Bankscope Database, 2007

Table 4: Description of the environmental variables using in the analysis

Environmental Variables	Description	Data Source
Macro Economic Condition		
Density of Population	Population per square kilometres	IMF
GDP	Gross Domestic Product	As above
GDP per capita	Ratio of GDP over inhabitants	As above
Inflation	Average CPI (Consumer Price Index). The base year is 2000	As above
Unemployment Rate (%)	Ratio of unoccupied inhabitants over the total population	As above, China Statistics Year Book (1998-2006), CIA- The World Fact book
Density of Demand	Ratio of total deposits over areas	Individual country's central bank website
Banking Structure		
Concentration	Assets of three largest banks as a share of assets of all commercial banks	World Bank (Database on the Financial Development and Structure)
Net Interest Margin	Accounting value of bank's net interest revenue as a share of its interest-bearing (total earning) assets	As above
Bank Overhead Costs	Accounting value of a bank's overhead costs as a share of its total assets	As above
Average Capital ratio (%)	Ratio of equity to total assets	Individual country's central bank website
Intermediation ratio	Ratio of total value of loans over total value of deposits	Individual country's central bank website
Accessibility of banking services		
Density of Branches	Number of branches per square kilometres	Individual country's central bank website

Table 5: Summarized values of environmental variables in the Asian countries (Year 2005)

	China	Hong Kong SAR	India	Indonesia	Malaysia	Philippines	Singapore	South Korea	Taiwan	Thailand
Macro Economic Condition										
Z1: Population Density	136.204	6193.435	369	114.2	78.679	284.2	6167.6	483.09	633.2	126.67
Z2: GDP	8944055	245591	3798812	902752	293563	435528	134330	1088845	657356	565791
Z3: GDP per capita (million US dollar)	0.0068	0.0359	0.0035	0.0041	0.0113	0.0051	0.0309	0.0226	0.0289	0.0087
Z4: Inflation	106.971	93	121.54	155.93	109.064	129.767	103.285	117.833	103.453	111.897
Z5: Unemployment ratio %	4.2	5.6	8.9	13.5	3.6	7.4	3.1	3.7	4.1	1.4
Z6: Density of Demand	1.52769	654.411	0.063	0.1915	1.6573	0.7042	207.0381	7.576	39.23	0.9496
Banking Structure										
Z7: Concentration	0.785581	0.739192	0.3695	0.6165	0.4983	0.5993	0.9966	0.4962	0.3022	0.4809
Z8: Net Interest Margin	0.02268	0.03014	0.0286	0.0475	0.0244	0.0395	0.02393	0.03	0.0192	0.0296
Z9: Overheads ratio	0.010784	0.02178	0.020911	0.0286	0.0141	0.0571	0.0083	0.0158	0.015	0.0176
Z10: Average Capital ratio%	4.27	8.2	12.8	19.6	12.9	11.8	9.8	12.43	10.34	14.16
Z11: Intermediation ratio	0.69	0.57	0.65	0.61	0.78	0.72	0.84	1.09	0.72	0.8997
Accessibility of Banking Services										
Z12: Density of Branches	0.0086	1.2626	0.023	0.004	0.006	0.0014	0.4347	0.051	0.17	0.008

Source: IMF, World Economic Outlook Database, April 2007, World Bank (Database on Financial Development and Structure)

Table 6: Estimated average efficiency score from Panel Data Models without Incorporating the Heterogeneous Factors

	Time invariant Models		Time varying Models*	
	FE	RE (Pitt & Lee)	B&C	True RE
Whole Sample Efficiency Score				
Mean (Standard Dev.)	0.29202 (0.1495)	0.3785 (0.1494)	0.3702 (0.1505)	0.8997 (0.0633)
Country Specific Efficiency Score				
China	0.2524 (0.1010)	0.3396 (0.1104)	0.3335 (0.1165)	0.9266 (0.0433)
Hong Kong SAR	0.3264 (0.1208)	0.4145 (0.1263)	0.3969 (0.1188)	0.9136 (0.0496)
India	0.2547 (0.0774)	0.3463 (0.0811)	0.3409 (0.0845)	0.9152 (0.0355)
Indonesia	0.3330 (0.1526)	0.4055 (0.1571)	0.3946 (0.1439)	0.8742 (0.0570)
Malaysia	0.4831 (0.2722)	0.5773 (0.2395)	0.5690 (0.2455)	0.9090 (0.0617)
Philippines	0.2893 (0.0956)	0.3637 (0.0985)	0.3950 (0.1615)	0.8681 (0.0747)
Singapore	0.4820 (0.3276)	0.5561 (0.2716)	0.5434 (0.2824)	0.8697 (0.0901)
South Korea	0.2661 (0.0381)	0.3801 (0.0415)	0.3637 (0.0436)	0.9094 (0.0322)
Taiwan Province of China	0.2901 (0.1089)	0.3844 (0.1187)	0.3718 (0.1239)	0.8953 (0.0829)
Thailand	0.1174 (0.0435)	0.1754 (0.0536)	0.1675 (0.0567)	0.8427 (0.0990)

* For time-varying models, we report the cost efficiency score for year 2005.

Figure 1 (a)

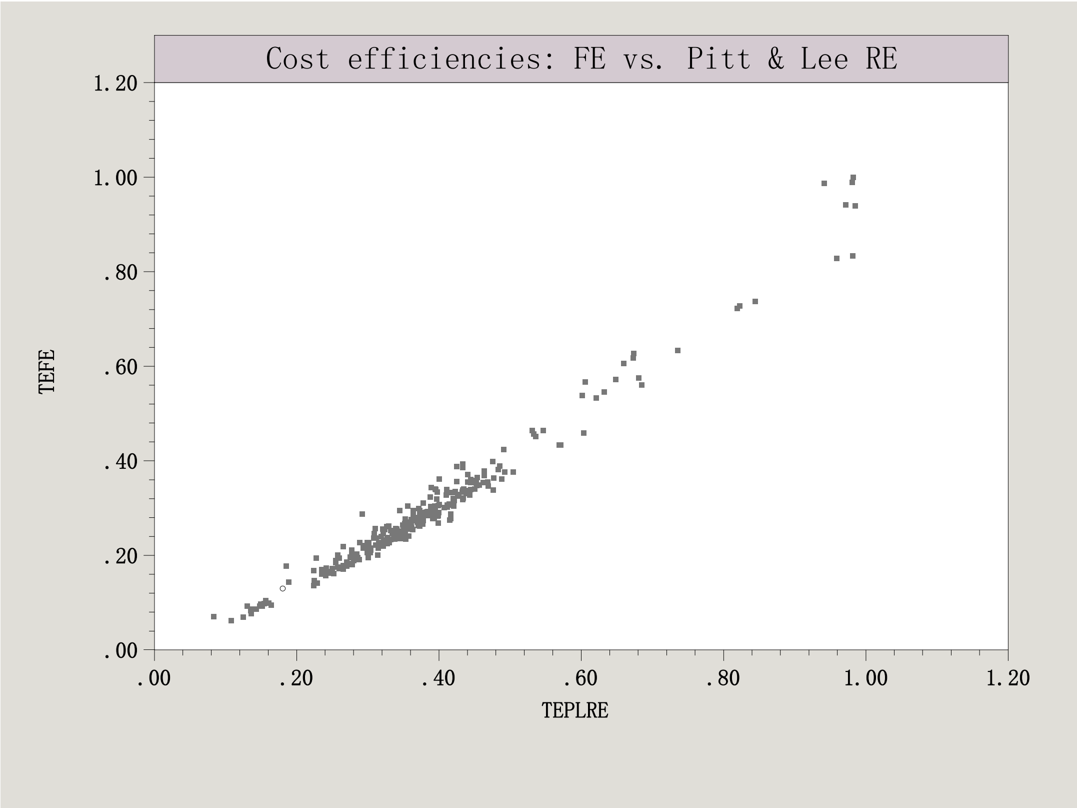

Figure 1 (b)

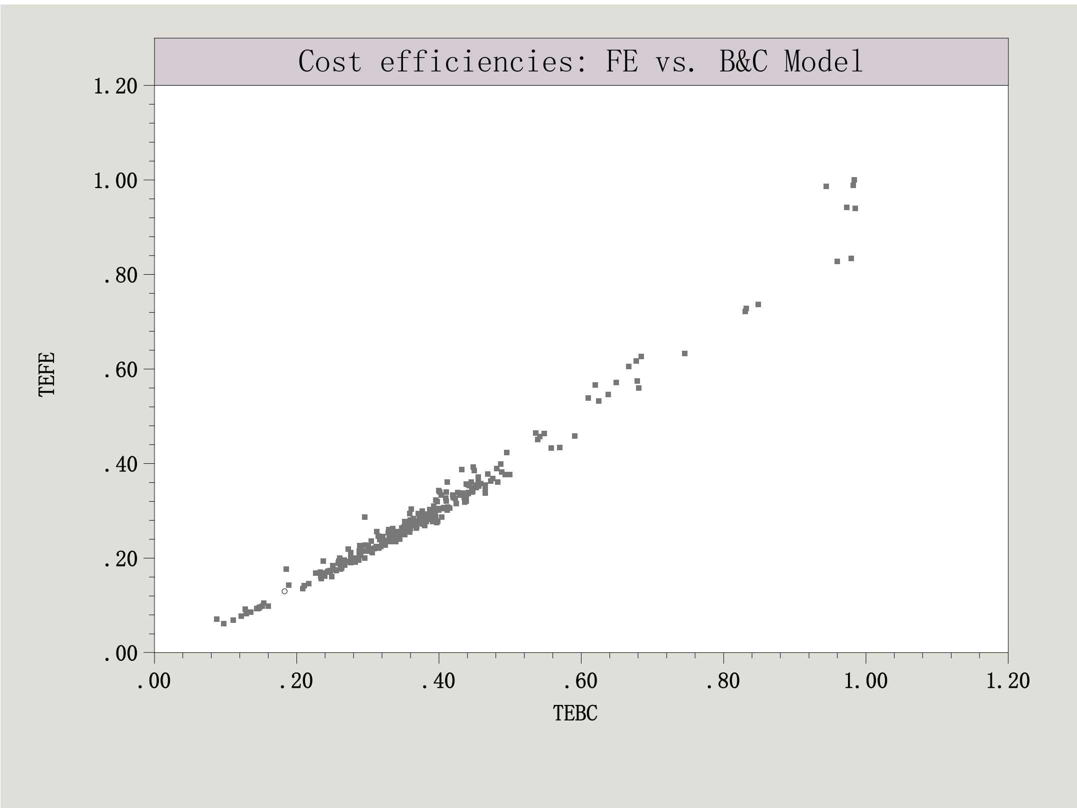

Figure 1 (c)

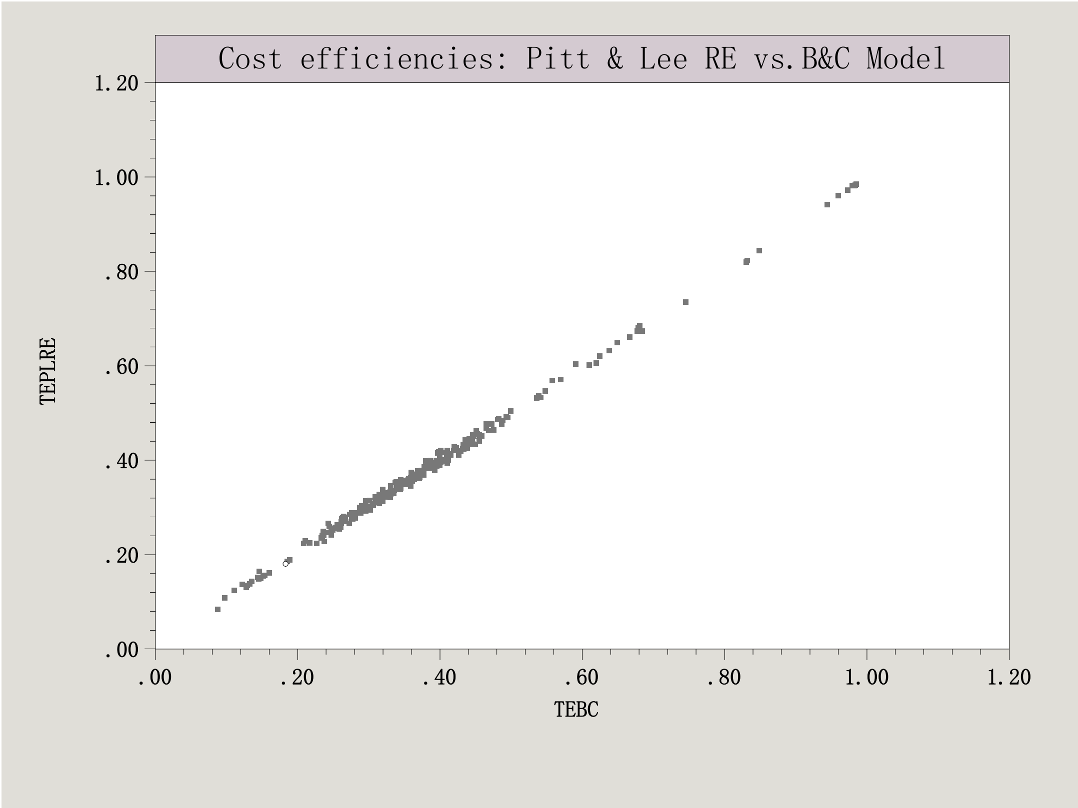

Table 7: Correlation Matrix for Estimated cost efficiency from Models without cross country environmental variables

	FE	**RE(P&L)**	**BC**	**True RE**
FE	1.00000	.98621	.98878	-.01680
RE(P&L)	.98621	1.00000	.99845	.01322
BC	.98878	.99845	1.00000	.00908
True RE	-.01680	.01322	.00908	1.00000

Table 8: Estimated Panel Data Models with Heterogeneous Factors

	Time Invariant Models	Time Varying Models
	Pitt & Lee RE	**B&C**
Constant	-0.380 (-8.400)**	-0.431 (-10.289)**
Y1	0.557 (44.505)**	0.541 (43.462)**
Y2	0.323 (20.795)**	0.308 (20.368)**
Y3	0.059 (8.450)**	0.053 (7.636)**
W1	0.682 (75.475)**	0.718 (80.740)**
W2	0.201 (24.983)**	0.164 (19.487)**
lnE	-0.028 (-3.730)**	-0.026 (-3.753)**
Y11	0.058 (36.157)**	0.058 (37.196)**
Y12	-0.129 (-31.303)**	-0.132 (-32.038)**
Y13	0.013 (6.337)**	0.012 (5.854)**
Y22	0.082 (27.909)**	0.081 (26.514)**
Y23	-0.041 (-16.081)**	-0.040 (-15.225)**
Y33	0.016 (13.602)**	0.016 (13.504)**
W11	0.041 (16.974)**	0.041 (16.896)**
W12	-0.065 (-14.385)**	-0.061 (-13.805)**
W22	0.025 (9.225)**	0.020 (7.812)**
Y1W1	-0.018 (-5.762)**	-0.015 (-4.969)**
Y1W2	0.018 (5.245)**	0.014 (4.285)**
Y2W1	0.058 (12.323)**	0.054 (11.686)**
Y2W2	-0.038 (-7.661)**	-0.035 (-7.237)
Y3W1	-0.014 (-5.083)**	-0.012 (-4.095)**
Y3W2	0.003 (1.246)	0.002 (0.589)
K1	0.120 (6.867)**	0.118 (8.414)**
K3	-0.391 (-14.049)**	-0.423 (-18.867)**
K4	0.350 (11.096)**	0.163 (4.210)**
K5	-0.076 (-7.119)**	-0.054 (-5.217)**
K7	-0.125 (-4.087)**	-0.128 (-4.608)**
K8	-0.043 (-2.183)*	-0.082 (-4.369)**
K10	-0.075 (-5.212)**	-0.083 (-5.570)**
K11	-0.063 (-2.758)**	-0.001 (-0.051)
σ_u	0.800 (12.056)**	0.881 (16.329)**
σ_v	0.111	0.108
λ	7.230 (4.353)**	8.126 (840.426)**
σ	0.808	0.887
η		-0.024 (-11.754)**
L.L.F.	897.2789	925.6985

All variables are in log terms. Estimated t-ratios are reported in the parentheses.
** indicates significant at 95% level. * indicates significant at 90% level.

Table 9: Estimated average efficiency score from Panel Data Models when Incorporating the Heterogeneous Factors

	Time invariant Models	Time varying Models*
	RE (Pitt & Lee)	B&C
The Whole Sample Efficiency Score		
Mean (Standard Dev.)	0.5191 (0.1791)	0.4998 (0.1958)
Country Specific Efficiency Score		
China	0.5146 (0.1256)	0.5081 (0.1428)
Hong Kong SAR	0.4349 (0.1153)	0.3831 (0.1084)
India	0.7089 (0.1213)	0.7161 (0.1345)
Indonesia	0.5183 (0.1727)	0.4807 (0.1568)
Malaysia	0.5975 (0.2094)	0.5776 (0.2194)
Philippines	0.5096 (0.1166)	0.5064 (0.1283)
Singapore	0.6311 (0.2100)	0.5818 (0.2401)
South Korea	0.4265 (0.0510)	0.3700 (0.0418)
Taiwan Province of China	0.4038 (0.1133)	0.3605 (0.1222)
Thailand	0.2460 (0.0566)	0.2148 (0.0613)

* For Battese and Coelli model, we report the cost efficiency score for year 2005.

Figure 2

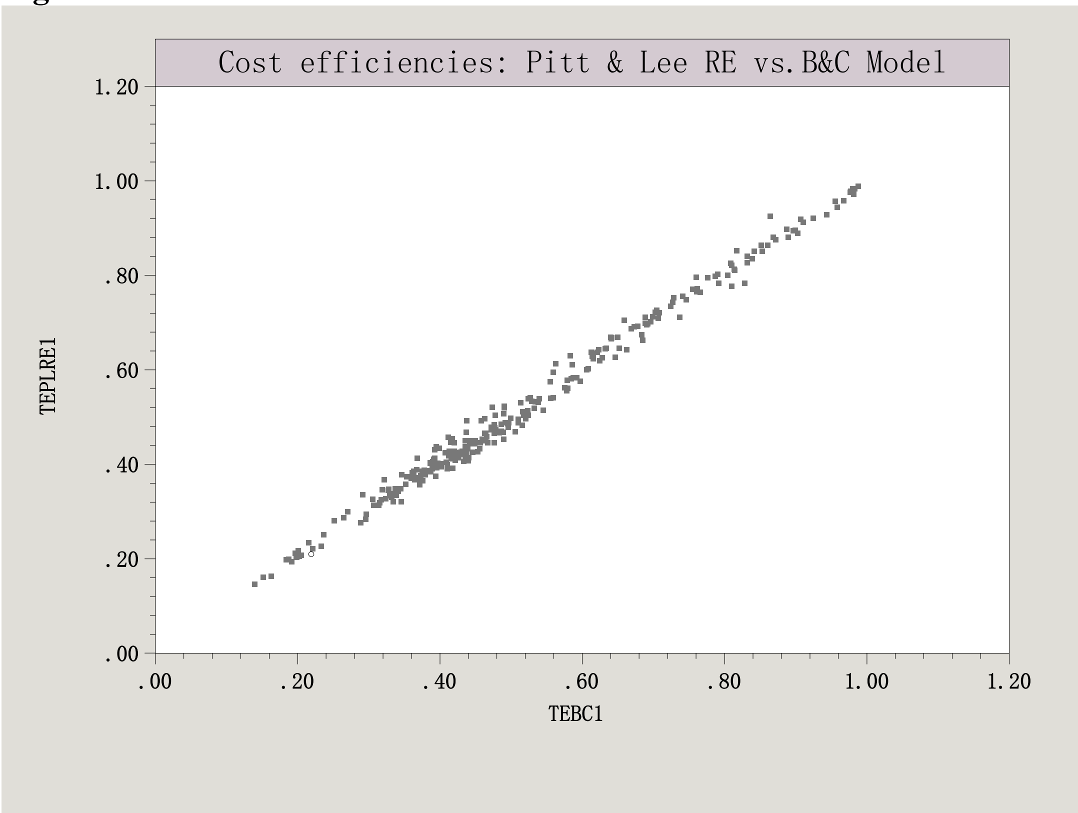

Table 10: Correlation Matrix for Estimated cost efficiency from model incorporating cross country heterogeneity

	RE(P&L)	**BC**
RE(P&L)	1.00000	.99248
BC	.99248	1.00000

Table 11: The expected and observed influence of the environmental variables on the banking costs

	Main Economic Indicators				Banking Structure			
	Population Density	GDP per capita	Inflation	Unemployment	Banking Concentration	Net interest margin	Capital Raito	Intermediation ratio
Expected	**-**	+ **or -**	+	**-**	+ **or -**	**-**	**-**	**-**
Pitt and Lee model	+	**-**	+	**-**	**-**	**-**	**-**	**-**
Battese and Coelli model	+	**-**	+	**-**	**-**	**-**	**-**	*

* indicates that the coefficient is insignificant.