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**Article**

## The effects of risks and environmental factors on bank cost efficiency: A study in East Asia and Pacific region

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## FINANCIAL ECONOMICS | RESEARCH ARTICLE

# The effects of risks and environmental factors on bank cost efficiency: A study in East Asia and Pacific region

Thu Phan<sup>1\*</sup>, Kevin Daly<sup>2</sup> and Anh-Tuan Doan<sup>1</sup>

**Abstract:** The interrelationship between risks and bank efficiency has received much attention in banking literature for years, especially after the Asian financial crisis in 1997 and the global financial crisis (GFC) in 2008. This study collected and analyzed the data of 247 banks of 12 developed and developing economies in East Asia and Pacific area over the 2003–2012 period to find the empirical evidence for that relationships. Using a stochastic frontier approach (SFA) to estimate bank cost efficiency, we found that there are significant relationships among risks, cost efficiency and environmental factors, but they are in different levels when comparing between developed and developing economies, or between the periods of pre- and post-2008 financial crisis.

**Subjects:** Economics; Corporate Finance; Banking

**Keywords:** bank efficiency; bank risks; bank performance; SFA; stochastic frontier approach; Asian developed economies; Asian developing economies; efficiency and risks relationship

### 1. Introduction

The financial system plays an important role in modern economies, and the intermediary function of the banking industry has a core role in influencing economic growth (Klein, 1971; Opie & Schumpeter, 1934). For this reason, the efficiency of banks has long been a conventional focus at both the theoretical and empirical levels. In this context, efficiency refers to the ability of banks

### ABOUT THE AUTHORS

Dr Thu Phan has been working as a lecturer in Finance and Banking at Da Lat University since 2000. She had completed her doctoral degree under the supervision of Professor Kevin Daly, School of Business, Western Sydney University.

Professor Kevin Daly's research passion revolves around applied finance and open economy macroeconomics, researching the effects of financial volatility on real economic activity. His current research interests focus on banking in China and Vietnam, foreign direct investment in China and Vietnam and financial volatility of stock markets in South East Asia.

Dr Anh-Tuan Doan, also a lecturer of Da Lat University, specialized in corporate governance, financial economics, bank efficiency and financial institutions management.

### PUBLIC INTEREST STATEMENT

Are people usually taking risks for an expected outcome? This topic is quite popular for all the fields of the society and attracting researchers, especially research on finance and banking. Banking industry as an intermediation has found that there are significant relationships between risks they take and their financial performance. Those relations may vary from different kinds of banks, such as private or state-owned ones; different groups of economies, at developing or developed level; and also vary from time to time, especially after some special event like financial global or regional crisis. Motivated by those variations, this study tried to examine the effects of three kinds of bank risks, including credit, liquidity and operational risk, on bank performance, measured by cost efficiency in East Asia and Pacific banking industry. The study found different significant risk-efficiency relationships by economies, developing and developed countries in the mentioned region.

to generate revenue from a given number of assets and make a profit from a given source of income (EuropeanCentralBank, 2010). In terms of the industrial level, the effectiveness of a banking system is demonstrated by its ability to provide services and maintain the stability of the system (Ngo, 2012). It is essential to understand and manage the efficiency of financial intermediation, especially within banks, as improvements in efficiency can lead to increase in profitability and the number of funds intermediated, as well as suitable prices and better service for customers. This is beneficial for both the banking industry and economic development (Berger, Hunter, & Timme, 1993b).<sup>1</sup>

There are evidences for the relationships between efficiency and risks of banking industry around the world. For example, a study of Berger and DeYoung (1997) found the negative effect of risk in cost efficiency at the banking industry level, narrowed down to the failure banks only. From another view, Fiordelisi et al. in their study in 2011 tried to have a deeper sight into this relationship by diversifying the measurements of credit risks. In general, they also found that higher risk bank led to lower efficiency, which is confirmed as “bad management hypothesis”. Provided a broader finding on the effects of several risk measure on bank performance, Sun and Chang in their study in 2011 found both negative and positive relationships among different kind of risks and bank inefficient scores.

Reviewing literature showed that much research has been conducted using the data of the banking industry throughout the world, particularly in the USA, Europe, and emerging Asian countries; however, few studies have compared the relationship between bank efficiency and risk in developing and developed countries. In addition, a study on the effects of macroeconomic factors and the effects of the economy and financial market shocks on banks’ activities is needed. The Basel Accords provide guidance for bank risk management, and the capital requirement ratio is proved to have an effect on a bank’s operation; therefore, this study added a regulation factor, capital requirement ratio in detail, as representing environmental factors. Consequently, this paper will add to the banking literature the study on the relationship between banks’ cost efficiency and risks and environmental factors, by comparing developing and developed economies in a specific geographic area.

There are still some limitations of previous studies that prevented us from having a big picture of risk and cost management around the world. First, the mentioned authors’ findings are only limited in separated groups of countries: developing or developed, there is still a lack of study that should be worked in the same data set to compare the effects between groups. In addition, according to the author’s knowledge, there are few studies related to this field conducted in East Asia and Pacific area as a specific area having representatives on both developed and developing markets. Second, because of the available data, the effects of some environmental factors as macroeconomics indicators have not been examined to the acceptable limit. Third, because of the observed period of previous studies mostly before 2009, there is no enough time to examine the effects of global financial crisis (GFC) and needs an updated research for the period of at least 5 years after 2008.

Despite the challenging external environment, the World Bank says this area, which includes all levels of economic development (underdeveloped, developing and developed), has enjoyed remarkable economic growth in the last four decades. The 1997–1998 East Asian financial crisis, which mainly affected Indonesia, Korea, Malaysia, the Philippines, and Thailand, revealed substantial vulnerabilities in the financial sector, namely, excessive borrowing, weak regulatory and supervisory frameworks, concentrated bank ownership and family control of banks. Economies in the region have made significant progress in running current account surpluses and building up large exchange reserves, as an insurance policy against crises (WorldBank, 2007). Several countries are experiencing rapid changes in economic development, population growth and urbanization, social transformation and technological development (WorldBank, 2014). The East Asia and Pacific region have been

emerged as the largest recipient of the developing world capital flows. Therefore, the region's financial markets and banking sectors play a core role in the world financial market (APFED, 2005).

This study aimed to examine the relationship between risks and environmental factors and bank cost efficiency, by comparing developing and developed economies in a specific geographic area. Asia and Pacific regions with 12 chosen economies are quite representative for two different levels of economics development. In specific, the sample is divided into two different groups that represent developed economies, such as Australia, Hong Kong, Japan, Korea, New Zealand and Singapore, and developing ones, such as China, Indonesia, Malaysia, the Philippines, Thailand and Vietnam. Stochastic frontier approach (SFA) was employed to estimate efficiency and to investigate the effects of credit, operational and liquidity risks and environmental factors on bank efficiency both before and after the 2008 GFC. We use the single-step estimation procedure in the analysis: measuring banks' cost efficiency and examining the relationship between cost efficiency and risk.

Testing the relationships among three kinds of risks and bank's cost efficiency which is estimated using SFA, we found the significant effects. Those effects examined and showed difference from groups of economies divided by the level of development. We also found that the mentioned relationships vary basing on data time divided by GFC event.

The rest of this paper proceeds with four remaining sections. Section 2 reviews literature on bank's cost efficiency, risks and the relationships between them. Section 3 describes data and methods. Section 4 explains main results, other results and discussions on them. The last section is conclusion which summarizes the key main points and findings of the paper.

## 2. Literature review

### 2.1. Evidence on bank efficiency in East Asia and pacific region

Measuring the efficiency of a firm or a financial institution has a long history. The three most popular approaches are ratio analysis, scale and scope efficiencies, and X-efficiency. The first two methods have limitations regarding measuring and comparing bank efficiency and were recently replaced by the third approach. Two outstanding features of the X-efficiency approach are data envelopment analysis (DEA) and SFA. DEA has been applied in many studies measuring bank efficiency, but it has the disadvantage of attributing measurement errors and other noise to the efficiency scores, which can cause the inefficiency estimated to be overstated (Wezel, 2010). SFA overcomes this limitation and decomposes the residual of the frontier into the inefficiency and the noise using explicit assumptions about the inefficiency component's distribution (Irsova & Havranek, 2011). Empirical studies on bank efficiency have been conducted using data from the banking industry around the world in both developed and developing countries. For example, studies have been conducted in Europe by Dietsch and Lozano-Vivas (2000), Maudos, Pastor, Pérez & Quesada (2002) and Resti (1997). Other research has been conducted in Japan (Hensel, 2006), Australia (Shamsuddin & Xiang, 2010), across countries (Berger & Humphrey, 1997; Pasiouras, Tanna, & Zopounidis, 2009), and in emerging markets such as India and East Asia (Dang-Thanh, 2010; Gardener, Molyneux, & Nguyen-Linh, 2011; Kalluru & Bhat, 2009; Sufian, Majid, & Zulkhibri, 2007; Vu & Turnell, 2010). Most of these studies have applied two approaches to measuring bank efficiency: DEA and SFA. SFA has been dominant in recent applications because of its advantage over DEA in terms of assuming statistical noise (Sun & Chang, 2011).

Research on banks' efficiency has attracted both theoretical and empirical interest, and many empirical studies have tried to identify the determinants of bank efficiency and to measure their efficiencies, in both developed and developing countries around the world. In terms of the theoretical aspect, although traditional theories of financial intermediation have been built on the models of resource allocation based on perfect and complete markets, contemporary banking theory has shown

that the unresolved issues remain, through an excellent survey on the current state of banking literature by Bhattacharya and Thakor (Bhattacharya & Thakor, 1993; Santomero, 1997).

## 2.2. Risks and bank efficiency

Scholars and analysts have recently grouped banking risk into various categories. Santomero (1997) divided risk into six types, based on the services provided by banks: systematic or market risk (interest rate risk), credit risk, counterparty risk, liquidity risk, operational risk and legal risks. Some of these groups overlap; for example, credit risk and counterparty risk are quite alike. In their book *The essentials of risk management*, Crouhy, Galai, and Mark (2006) classified risks into eight different groups: credit risk, market risk, liquidity risk, operational risk, legal risks, strategic risk, business risk and reputation risk. This classification is quite comprehensive, although not specifically related to only banks (Crouhy et al., 2006). There is an agreement between two mentioned categories related to some main kinds of risks, including credit risk, market risk and operational risk. These main risks are also grouped and classified under the first “pillar” in the Basel Accords, issued by the Basel Committee on Bank Supervision<sup>2</sup>; all other risks are defined and grouped under the second “pillar” of the Accords (Dam, 2010). As mentioned earlier, Cornett and Saunders (2003), *Financial institutions management: A risk management approach*, list 10 types of risk: interest risk, market risk, credit risk, off-balance-sheet risk, technology risk, operational risk, foreign exchange risk, country or sovereign risk, liquidity risk and insolvency risk. The following paragraphs include in-depth definitions of each type of risk.

In the banking system, “credit risk” is directly related to the traditional functions of a bank and is “the risk that promised cash flow from loans and securities held by financial institutions may not be paid in full” (Cornett & Saunders, 2003). Throughout history, banks have managed this risk as a main part of their business. However, since the Bank for International Settlements (BIS) Accord first set out a formalized universal approach to credit banks, it has become one of the greatest concerns of scholars, analysts and empirical managers. Based on the first BIS Accord, banks were required by their regulators to set aside a flat-fixed percentage of their risk-weighted assets as regulatory capital against default (Crouhy, Galai, & Mark, 2000). More formally, “credit risk arises whenever a lender is exposed to loss from a borrower, counterparty, or an obligor who fails to honour their debt obligation as they have agreed or contracted” (Dam, 2010). In the operation of the banking industry, credit failures are not rare, and they have direct, critical effects on various aspects of a bank, such as the bank’s liquidity, cash flows, profitability and eventually, reputation, which is why credit risk management has become a hot topic of debate. As well as research on credit risk management in developed countries, such as Europe and the USA (Fiordelisi, Marques-Ibanez, & Molyneux, 2011; Pastor, 2002), this topic also has been researched by using cross-countries data (Ali and Daly, 2010; Berger & DeYoung, 1997; Bonfim, 2009) and in emerging-market economies (Dam, 2010; Godlewski, 2005).

Another type of risk that has recently concerned banks is operational risk. Although this kind of risk may represent a significant share of a bank’s total risk, it has only recently been added to the risk catalogue of the Basel Accord. One definition of operational risk is: “the risks that existing technology, auditing, monitoring, and other support systems may malfunction or break down” (Cornett & Saunders, 2003). However, operational risk is still not a well-defined concept and is not easy to measure. In the context of intermediation activities, it refers to a wide range of possible failures in the operation of the organization that are not directly related to market or credit risk. Operational risks are associated with inadequate systems, management failure, faulty controls and human errors (Crouhy et al., 2000).

Liquidity risk is a major risk that banks face, as debt maturity transformation is one of their key business areas. Cornett and Saunders define it as: “the risk that a sudden surge in liability withdrawals may require a financial institution to liquidate assets in a very short period of time at less than fair market prices” (Cornett & Saunders, 2003). This risk happens when a bank “will not be able to meet its current and future cash flow and collateral needs, both expected and unexpected, without materially affecting its daily operations or overall financial condition” (Lopez, 2008). In their 2013 guidance on liquidity risk management, the Basel Committee noted that a liquidity shortfall at a single institution

can have system-wide repercussions and financial market developments in the past decade have increased the complexity of liquidity risk and its management (BIS, 2013).

The interrelationship between risk and bank efficiency has received much attention in recent years, particularly after the 1997 Asian Financial Crisis and the 2008 GFC. One of the earliest studies that focused on the effects of risk on efficiency was in 1997, by Berger and DeYoung. They employed Granger-causality techniques to test four hypotheses—the “bad management” hypothesis, the “bad luck” hypothesis, the “skimping” hypothesis and the “moral hazard” hypothesis—to show the relationship between credit risk and efficiency. Their results suggested that loan quality has both negative and positive effects on efficiency; particularly, there is a negative relationship between cost efficiency and risk in failed banks (Berger & DeYoung, 1997). Although Berger and DeYoung’s study was an intensive analysis of risk effects, its procedure, based on the Granger-causality test, did not cover the causes of credit risk at the individual bank level, but came to a broader result at the industry level (Pastor, 1999, 2002). To overcome the limitations of the previous studies in terms of credit risk measurement, a 2011 study by Fiordelisi et al. used diverse measures of credit risk, including non-performing loans, 1-year-ahead expected default frequency, and 5-year-ahead expected default frequency, to examine its effects on efficiency through three separate models. In addition, this study not only focused on cost and profit efficiency but also estimated revenue efficiency and conducted robustness checks with the other measures. In general, their results showed “lower bank efficiency with respect to costs and revenues Granger-causes higher bank risk, thus confirming the ‘bad management hypothesis’” (Fiordelisi et al., 2011).

The literature review part gives a big picture of what has been done and has not been mentioned so far in doing research on bank efficiency and risks. As in most of the research topics, research in this mentioned field has been conducted with the data across countries, such as USA, Europe and several developed Asian countries. However, research on comparing the relationship between efficiency and risks of banks in developing and developed economies is still limited.

In addition, it is proved that macroeconomic factors, policies or regulations, and also the economy and financial market shocks, have had significant impacts on banks’ activities and performance. That is why this study examined the effects of those mentioned external factors on the relationship of banks’ performance and risks and added to the literature the significant findings from that examination.

### **3. Data and methods**

#### **3.1. Data sources**

An unbalanced panel data of banks covering the 2003–2012 period were analyzed. The financial data, such as financial statements and other financial ratios, were mostly taken from Bankscope, a comprehensive world banking information source provided by Bureau van Dijk. The data sets of the banking sectors of the 12 East Asia and Pacific economies in the study were employed, a total of 247 banks. An average of 20 banks in each economy was intended, but in the cases of New Zealand and Singapore there were less than 10 banks. To avoid a domination of any country out of 12, we start collecting bank’s financial statement data with a maximum of 50 largest banks by total assets in each country.<sup>3</sup> As our paper focuses on commercial banks, we start by dropping central banks, investment banks, securities houses, multilateral government banks, non-banking credit institutions and specialized government financial institutions. That scope built an unbalanced panel data consisting of 2,378-year-bank observations for the 10 years from 2003 to 2012. The detail distribution of observations across economies is shown in Table 1.

#### **3.2. Measurement of cost efficiency**

The first aim of this study was to measure the efficiency of East Asia and Pacific banking industries. In-line with Berger and Mester (1997), we measure cost efficiency by how close a

**Table 1. Unbalanced panel data descriptions**

Year	Numbers of observations	Numbers of banks	Area	Numbers of observations	Numbers of banks
2003–2012	2378	247	East Asia & Pacific area	2378	247
2003–2007	1154	247	Developed economies	1046	108
2008–2012	1224	247	Developing economies	1332	139
2003	202	247	Australia	108	13
2004	217	247	New Zealand	36	4
2005	240	247	Hong Kong	175	18
2006	247	247	Japan	500	50
2007	247	247	Korea	160	16
2008	247	247	Singapore	67	7
2009	247	247	China	251	26
2010	247	247	Indonesia	337	34
2011	246	247	Malaysia	203	21
2012	237	247	Philippines	184	19
			Thailand	198	20
			Vietnam	159	19

Note: This table shows the number of observations and banks in the unbalanced panel data of East Asia and Pacific area over 2003–2012 period.

bank’s actual cost is to what a best practice bank’s cost would be for producing identical output under the same conditions. As discussed earlier, cost efficiency can be achieved using one of two common approaches: the parametric SFA and the nonparametric DEA. While DEA is built under the assumptions that there is no random error, SFA “specifies a functional form for the cost, profit, or production relationship among inputs, outputs, and environmental factors, and allows for random error” (Berger & Humphrey, 1997). Indeed, SFA approach modifies the traditional assumption of a deterministic production frontier which got its advantage (Sun & Chang, 2011).<sup>4</sup> Using SFA to measure efficiency scores, it, therefore, helps us to control for measurement error and other random effects and has, therefore, been widely applied to banking and other industries (Aigner, Lovell, & Schmidt, 1977; Berger & Mester, 1997; Kumbhakar & Lovell, 2000). Following Battese and Coelli (1997) and Bonin, Hasan, and Wachtel (2005), we conduct the stochastic frontier estimation using a translog specification of cost function to obtain efficiency scores across countries, based on the assumption that efficiency differences among banking industries are determined by country-specific characteristics.<sup>5</sup> The cost model can be written in its general form as follows:

$$TOTALCOST_{it} = f_1(Y_{it}, P_{it}) + v_{it} + u_{it} \tag{1}$$

$$v_{it} \sim N(0, \sigma_v^2) \text{ and } u_{it} \sim N^+(\mu_{it}, \sigma_u^2) \tag{2}$$

$$\mu_{it} = \delta_0 + \sum_n \delta_{n,it} Z_{n,it} \tag{3}$$

where  $TOTALCOST_{it}$  is total costs of bank  $i$  at time  $t$  and  $f_1(Y_{it}, P_{it})$  is the cost frontier. In this model, bank efficiency is measured in relation to a global best practice frontier. In Equation (1),  $Y_{it}$  represents the logarithm of the output of bank  $i$  at time  $t$ ,  $P_{it}$  is a vector of the logarithms of the input prices of bank  $i$  at time  $t$ ,  $u_{it}$  captures cost inefficiency and is independent and identically distributed with a truncated normal distribution. Hence, the total costs a bank faces are never lower than the costs of the frontier (see Berger, Hancock, & Humphrey, 1993a for a



graphical representation of the frontier and its dynamics),  $v_{it}$  captures measurement error, and random effects are distributed as a standard normal variable. Both  $u_{it}$  and  $v_{it}$  are represented in Equation (2) as time and bank specific. It is also crucial to note that Equation (3) models inefficiency and its explanatory variables, where  $z$  is the vector of  $n$  variables that drive the inefficiency of bank  $i$  at time  $t$ . The deltas represent the coefficients. Equations (1) and (3) are solved in one step using maximum likelihood estimation in which detailed descriptions of SFA are provided in the Appendix.

The cost (in)efficiency scores of individual banks,  $Inefficiency_i = \exp(u_i)$ , estimated from the SFA would take a value between one and infinity. However, to make our results comparable, we follow the methodology used by Pasiouras et al. (2009) to generate the index of cost efficiency as follows:  $COSTEFF_i = 1/Inefficiency_i$ . Thus, our dependent variable,  $COSTEFF$ , denotes efficiency score ranges between 0 and 1 with values closer to 1 indicating a higher level of bank efficiency. To examine the effects of risks on (in)efficiency while controlling for other bank- and country-specific characteristics,  $\mu_{it}$  in Equation (3) is specified in terms of  $COSTEFF$  in the Equation (4).

All of the variable measurements of this estimation, including total interest expenses, total non-interest expenses, total assets, total fixed assets, total short-term deposits, total long-term deposits, total loans, other earning assets and liquid assets, were available from the financial statements of sample banks, on the Bankscope database. Table 2 shows the definitions of all variables used in estimating cost efficiency.

The descriptive statistics of all variables are provided in Table 3. Some of the main indicators shown in Table 3 indicate the “big picture” of the East Asia and Pacific banking sector. It is clear that there is a large gap between the banks of developed and developing economies; the mean of developed banks’ total assets is almost double the size of the mean for developing banks.

### 3.3. Basic model

The following equation is used to estimate the relationships among three kinds of risks and efficiency:

$$COSTEFF_{i,c,t} = \beta_0 + \beta_1 Bank\ Risks_{i,c,t} + \alpha' Bank\ Controls_{i,c,t} + \gamma Bank\ Regulation\ Control_{c,t} + \rho' Macro\ Controls_{c,t} + Year\ Dummies + Country\ Dummies + e_{i,c,t}, \tag{4}$$

where  $COSTEFF_{i,c,t}$  is the cost-efficiency scores of bank  $i$  in country  $c$  in time  $t$ . The variable *Bank Risks* serve as a proxy for types of bank risk, including credit risk, liquidity risk and operational risk. In-line with Sun and Chang (2011), we measure credit risk by capturing the ratio of loan loss reserves over gross loans (LLRGL), which is used to capture output quality and how the manager invests in highly risky

Table 2. Variable definitions for estimating cost efficiency	
Variable	Definitions
TOTALCOST	Total interest expenses and non-interest expenses
TOTALLOAN	Total loans
OEASSET	Other earning assets
TOTALDEPOSIT	Total short-term deposits and long-term deposits
TOTALASSET	Total assets
LIQUIDASSET	Liquid assets
PCAPITAL	Price of capital—ratio of non-interest expenses to total fixed assets
PFUND	Price of fund—ratio of interest expenses to total deposits

Note: This table defines all variables used in estimating the cost-efficiency scores.

**Table 3. Sample descriptive statistics of variables used in estimating cost efficiency (2003–2012)**

	Full sample			Developed economies			Developing economies		
	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.
TOTALCOST (in thousand US\$)	2,211,279	1,182	72,900,000	2,739,106	7,895	33,800,000	1,796,785	1,182	72,900,000
<b>Output quantities (in thousand \$US)</b>									
GROSSLOAN	47,600,000	27	1,360,000,000	64,400,000	28,886	917,000,000	34,400,000	26	1,360,000,000
OEASSET	34,800,000	0	1,330,000,000	47,100,000	2,082	904,000,000	25,200,000	0	1,330,000,000
TOTALDEPOSIT	77,500,000	12,925	2,490,000,000	104,000,000	95,071	1,770,000,000	56,800,000	12,925	2,490,000,000
LIQUIDASSET	14,100,000	4,180	728,000,000	148,000,000	8,545	388,000,000	13,600,000	4,180	728,000,000
TOTALASSET	88,100,000	29,380	2,790,000,000	121,000,000	154,604	2,010,000,000	62,400,000	29,380	2,790,000,000
<b>Input prices</b>									
PCAPITAL	5.3339	0.0285	810.9945	8.1459	0.1179	810.9945	3.1257	0.0285	184.5000
PFUND	0.0277	0	0.1967	0.0174	0	0.1111	0.0359	0.0001	0.1967

Note: This table reports the minimum, maximum, average of all variables, which are defined in Table 4.2. All nominal monetary variables are transferred to the 2005 price level. The data source is Bankscope Database.

assets. Similarly, a set of two variables is used for accounting operational risk: the ratio of equity and total assets (ETA) and return on asset volatility (ROAV). In particular, the role of ETA is to capture financial distress and the probability of bankruptcy; ROAV is an accounting-based volatility indicator calculated by a logged 3-year standard deviation of ROA. The equity to asset ratio measures the equity position of a bank as a fraction of total assets. The ratio of cash and due from banks to total assets (CDTA) is used to measure liquidity risk (Altunbas, Liu, Molyneux, & Seth, 2000). The year and country effects are also considered and measured with year and country dummy variables.

We also employ six control variables, with two at bank level and four at banking industry and country levels. At the bank level (*Bank Controls*), log of TOTALASSET and TOTALDEPOSIT plays the role of bank size indicators, used to control banking scale (Bauer, Berger, Ferrier, & Humphrey, 1998; Berger, Hasan, & Zhou, 2009; Westman, 2011). *Bank Regulation Control* represents for key bank regulations stressed by the Basel Committee. Following Laeven and Levine (2009) and Barth, Caprio, and Levine (2013), we control bank regulatory by capital ratio requirement (REGULATION) on bank activities. Furthermore, *Macro Controls* are the vector of macroeconomic controls including economic growth (GDP) and inflation (CPI). To compare the different effects of bank risk on efficiency before and after GFC, we also employ a dummy variable (YCRISIS) that takes a value of one for the years 2008–2012 and zero otherwise. Moreover, following Sun and Chang (2011), two instrument variables for testing endogenous problem are used: Total Equity (EQUITY) and the ratio of liquid assets to total liabilities (LIQUIDRATIO). Table 4 lists all the variable definitions of the testing process.

Table 5 shows the statistics summaries of all of the variables. The statistics measurements of risks between groups of economies show that the means of the ratios of developing economies were much higher than the other group. Although a firm conclusion cannot be drawn from that data, it seems that the developing banking systems, with a mean ratio of ETA of around 10%, were operating more safely than the developed systems (7%). However, the ROAV in developing banking systems was double that of developed banking systems, indicating a highly volatile operating situation. The macroeconomic indicators show that the CPI and IR of developing economies were at higher volumes than are normal for emerging markets.

**Table 4. Variable definitions for testing the relationships between bank cost efficiency and risks**

Variables	Definitions
LLRGL	The ratio of loans loss reverses to gross loans
ETA	The ratio of equity to total assets
ROAV	The volatility of return on assets (ROA)
CDTA	The ratio of cash and due from bank to total assets
CPI	Consumer price index
IR	Interest rate
GDP	Gross domestic product (purchasing power parity) per capita
REGULATION	Capital ratio requirement
EQUITY	Total equity
LIQUIDRATIO	The ratio of liquid assets to total liabilities
YCRISIS	Dummy variable for the specific event: financial crisis 2008. It takes value “0” for the period before 2008, and value “1” for the remaining years from 2008.
DEVELOP	Dummy variable for two groups of countries: developed and developing. It takes value “0” for developing countries, and value “1” for the other group—developed countries.

Note: This table defines all variables used in testing the relationships between risks measures and cost efficiency.

**Table 5. Statistics of variables used in testing the relationships between risks and cost efficiency**

	Full sample			Developed economies			Developing economies		
	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.
<b>Risks measures</b>									
LLRGL (%)	3.125	0.005	80.149	1.436	0.015	15.639	4.452	0.005	80.149
ETA (%)	8.729	-27.489	74.123	7.104	-16.881	42.957	10.005	-27.489	74.123
ROAV	0.411	0	43.699	0.255	0	14.187	0.533	0	43.699
CDTA (%)	5.396	0.000035	98.313	4.251	0.0009	74.062	6.295	0.000035	98.313
<b>Control variables</b>									
CPI (%)	3.465	-2.6	25	1.304	-2.6	25	5.164	-0.9	23.1
IR (%)	4.232	0	15	1.835	0	8.4	6.115	0.3	15
GDP (US\$)	18,494	796	60,799	34,357	1,146	60,799	6,037	796	16,794
REGULATION (%)	5.905	3	8	5.65	3	8	6.104	3	8
<b>Instrument variables</b>									
EQUITY (in thousand \$US)	5,196,780	-99,600,000	179,421,710	7,249,949	-6,510,110	113,000,000	3,584,458	-99,600,000	179,000,000
LIQUIDRATIO (%)	20.162	0.138	189.982	13.039	0.138	114.175	25.756	0.355	189.982

Note: This table reports the average, minimum, and maximum of all variables, which are defined in Table 5.1. The data sources are Bankscope, WorldBank, and IMF Database.

## 4. Results and discussion

### 4.1. Main results

#### 4.1.1. Efficiency scores

Table 6 reports cost efficiency of East Asia and Pacific developed and developing economies over 2003–2012 period. The overall average of efficiency scores indicates that the observed banks could have produced their outputs using 62% of their actual inputs. Although the mean of the cost-efficiency scores is at the medium level, there is a large gap in cost management between the banks in the East Asia and Pacific banking system, in which the cost-efficiency scores range widely, from a very low 0.2% up to 98%.

The mean efficiency scores of the two groups of economies, in developing countries (i.e. China, Indonesia, Malaysia, Philippines, Thailand and Vietnam) and developed countries (i.e. Australia, New Zealand, Hong Kong, Singapore, Japan and Korea), showed a surprising result. The mean for developing countries was much higher (70%) than that of the developed countries (51%). However, this was mainly because Japan, which had around 50% of the developed group’s bank-year observations, had the worst level of cost efficiency, with mean scores of only 28% during the period 2003–2012. In fact, most of developed countries that were observed had mean efficiency scores that were equal to or higher than the overall score. Australia and New Zealand scored 82% and 86%, respectively, in-line with previous studies of developed countries (e.g. the USA, Germany, France, Italy and Spain), which also found average efficiency scores of around 80% (Berger & DeYoung, 1997; Pastor, 2002).

In the developing countries group, the two countries with the lowest efficiency (the Philippines and Thailand) scored around the average level, at about 60%. The efficiency scores of other countries in this group ranged from 72% (Malaysia) to 86% (Vietnam), leading to a group average of 70%. In a previous study on 12 transition economies in Central and Eastern Europe during the period 1993–2000, Yildirim and Philippatos measured bank cost efficiencies using both SFA and

**Table 6. Summary of cost-efficiency estimations of separated economies of East Asia & Pacific area over 2003–2012 period**

<b>COSTEFF of</b>	<b>Mean</b>	<b>Std. Dev.</b>	<b>Min.</b>	<b>Max.</b>
<b>East Asia &amp; Pacific area</b>	<b>0.6226</b>	<b>0.2423</b>	<b>0.0025</b>	<b>0.9808</b>
<b>Developed economies</b>	<b>0.5153</b>	<b>0.2936</b>	<b>0.0254</b>	<b>0.9808</b>
Australia	0.8187	0.1334	0.1315	0.9415
New Zealand	0.8565	0.0192	0.8177	0.9155
Hong Kong	0.6446	0.1751	0.1689	0.8732
Japan	0.2801	0.2055	0.0254	0.9031
Korea	0.7782	0.0855	0.3523	0.9808
Singapore	0.6282	0.2458	0.0794	0.9647
<b>Developing economies</b>	<b>0.7063</b>	<b>0.1459</b>	<b>0.0025</b>	<b>0.9714</b>
China	0.7329	0.0899	0.4371	0.9171
Indonesia	0.7319	0.1018	0.4021	0.9714
Malaysia	0.7174	0.1675	0.0025	0.9576
Philippines	0.5941	0.1358	0.1819	0.8526
Thailand	0.6014	0.1525	0.0360	0.8648
Vietnam	0.8603	0.0350	0.7381	0.9286

Note: This table reports the summary statistics of cost-efficiency scores (COSTEFF) across economies in East Asia and Pacific area over 2003–2012 period.

DEA. Their SFA results had an average score that was higher than the mean for our research, at around 77%. This score means about one-quarter of bank resources are wasted during the provision of banking services in transition economies, on average (Yildirim & Philippatos, 2007). The results of our analysis are comparable with those of a previous study in Asian emerging countries by Sun and Chang (2011), which were typically in the vicinity of 70%.

Table 6 also provides a picture of cost management of each economy in terms of their cost-efficiency score. Most of sampled banking systems had a wide range of bank efficiency scores; for example, New Zealand and Vietnam. Varied ranges in cost efficiency from the minimum scores to the maximum scores of those mentioned countries are only around 10% and 20%, respectively. In the other economies in the East Asia and Pacific area, minimum efficiency scores were less than 40%, even less than 10% in the cases of Japan, Singapore, Thailand and Malaysia. However, this cannot be used to draw any conclusions about the stability of their banking systems; further examination would be required for that. According to a study of European transition economies by Yildirim and Philippatos, Poland and Spain were the most efficient countries during the period 1993–2000, at 85% and 82%, respectively, while the Russian Federation and the three Baltic States were the least efficient, at around 70%.

Table 7 reports effects of financial crisis 2008 on cost efficiencies of separated groups of economies in East Asia and Pacific area. The means of the efficiency scores in groups of years are generally similar, at around 62%. However, the periods before and after the 2008 GFC show different trends. From 2003 to 2007, the means of the efficiency scores increased steadily from 59% to 66.5%; the scores declined after 2008, to less than 60% in 2012. It could be predicted that the GFC event would have an effect on efficiency scores and that the effects would be more marked for developed economies than for the developing group. Table 4.5 shows that the means for developed economies rose from 54% to 73.4% during the period 2003–2007; conversely, the average cost-efficiency scores of developing countries' banking systems was quite stable, with average scores across years of 70% for both the period before and after the GFC.

Figures 1 and 2 introduce the cost-efficiency scores of separated countries across years, divided into the two groups of developing level. These results enable a comparison of the trend in average cost-efficiency scores across countries from 2003 to 2012. The detailed data for these figures are shown in Table 7. Figure 1 shows that while Australia and Singapore had consistent trends, upwards and downwards, respectively, the cost efficiency of the other countries fluctuated widely during the period 2003–2012.

Figure 2 indicates two different trends among the developing countries. While the average cost-efficiency scores in Indonesia and the Philippines consistently declined, the scores of other countries in this group were very volatile over years, particularly in Malaysia.

A 2011 study on cost efficiency in Asian emerging countries by Sun and Chang showed some trends that were similar to our results, but in a different period: 1998–2008. Their study included five of the countries in our sample: China, Korea, Malaysia, Philippines and Thailand. Their results confirmed our results, with China presenting consistently higher cost efficiency and Thailand and the Philippines being in the lowest group of cost management.

#### 4.1.2. *Bank cost efficiency, risks, and environmental factors*

Table 8 reports our baseline results. As a problem can arise, related to multicollinearity, if all the risk measures were put into the same model, the process of testing the relationships went through four main models: models 1–3 examined the separate effects of credit risk, operational risk and liquidity risk, and model 4 examined the combined effects of three kinds of risk on cost efficiency, estimated from the last stage of this paper, over the period 2003–2012.

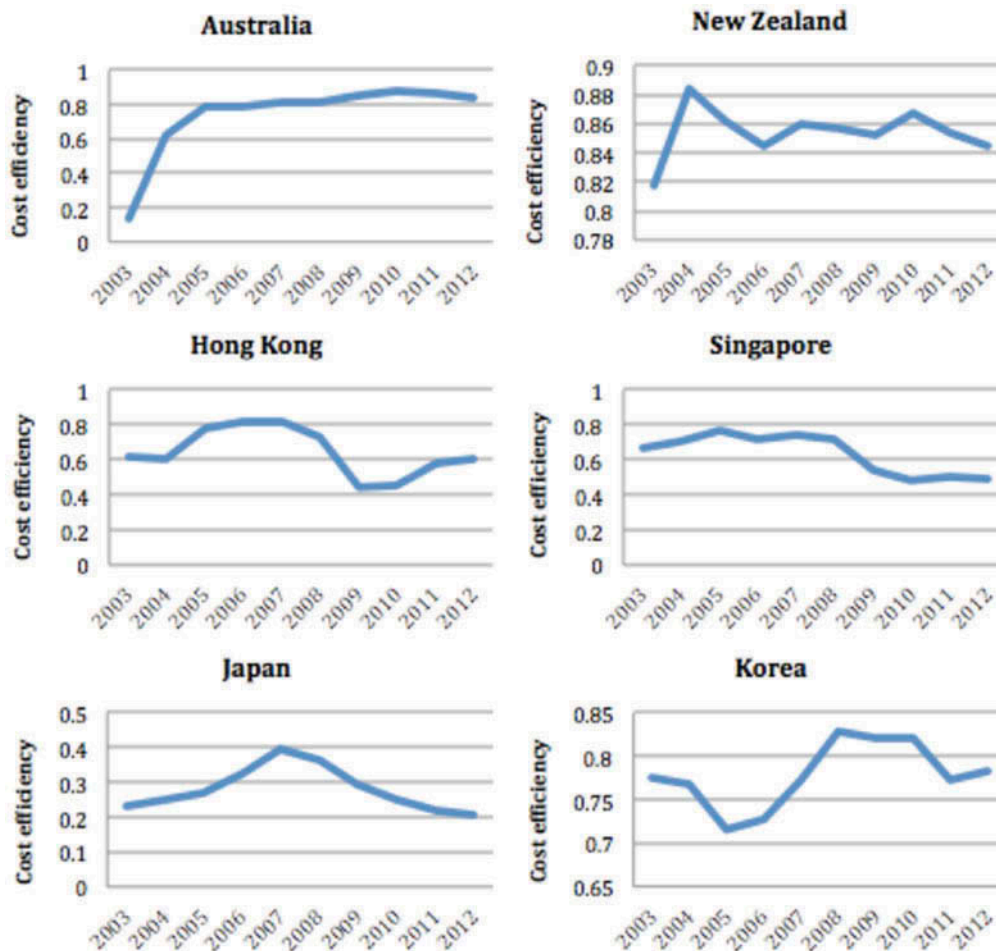
Table 8 reports estimations of the parameters from Equation (4) using cost-efficiency scores (COSTEFF) as a dependent variable. Model 1 examines credit risks measured by the ratio of LLRGL as a determinant

**Table 7. Means of cost-efficiency estimations of economies of East Asia & Pacific area across years**

Mean of COSTEFF	2003–2007	2008–2012	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
East Asia & Pacific area	0.6299	0.6159	0.5980	0.6014	0.6264	0.6501	0.6656	0.6564	0.6146	0.5976	0.6101	0.5996
Developed economies	0.6623	0.6471	0.5402	0.6377	0.6949	0.7046	0.7343	0.7177	0.6345	0.6228	0.6316	0.6286
Australia	0.6294	0.8171	0.1315	0.6210	0.7874	0.7906	0.8164	0.8171	0.8536	0.8721	0.8676	0.8432
New Zealand	0.8534	0.8573	0.8177	0.8841	0.8616	0.8441	0.8593	0.8573	0.8529	0.8675	0.8539	0.8447
Hong Kong	0.7274	0.7274	0.6161	0.6086	0.7738	0.8191	0.8194	0.7274	0.4420	0.4456	0.5779	0.6077
Japan	0.2942	0.3620	0.2330	0.2478	0.2685	0.3238	0.3979	0.3620	0.2935	0.2492	0.2219	0.2036
Korea	0.7518	0.8273	0.7753	0.7673	0.7155	0.7278	0.7730	0.8273	0.8196	0.8211	0.7726	0.7829
Singapore	0.7178	0.7153	0.6675	0.6976	0.7622	0.7220	0.7398	0.7153	0.5453	0.4812	0.4960	0.4897
Developing economies	0.7114	0.7017	0.7240	0.7156	0.6998	0.7115	0.7063	0.7087	0.6969	0.6849	0.7082	0.7096
China	0.7041	0.7450	0.7012	0.7188	0.6977	0.6888	0.7140	0.7450	0.7267	0.7320	0.7875	0.8091
Indonesia	0.7557	0.7042	0.8104	0.7580	0.7541	0.7531	0.7029	0.7042	0.7480	0.7099	0.7086	0.6749
Malaysia	0.7219	0.7166	0.7383	0.7292	0.7064	0.7044	0.7309	0.7166	0.7108	0.7138	0.6954	0.7345
Philippines	0.6562	0.5842	0.6704	0.6944	0.6766	0.6466	0.5929	0.5842	0.5865	0.5403	0.5035	0.4726
Thailand	0.5859	0.6316	0.5776	0.5301	0.5306	0.6398	0.6515	0.6316	0.5475	0.5335	0.6686	0.6980
Vietnam	0.8449	0.8708	0.8459	0.8632	0.8334	0.8365	0.8456	0.8708	0.8622	0.8799	0.8859	0.8686

Note: This table reports means of cost-efficiency scores (COSTEFF) of the economies in East Asia and Pacific area across years.

Figure 1. Cost efficiency for developed East Asia and Pacific economies over the 2003–2012 period.



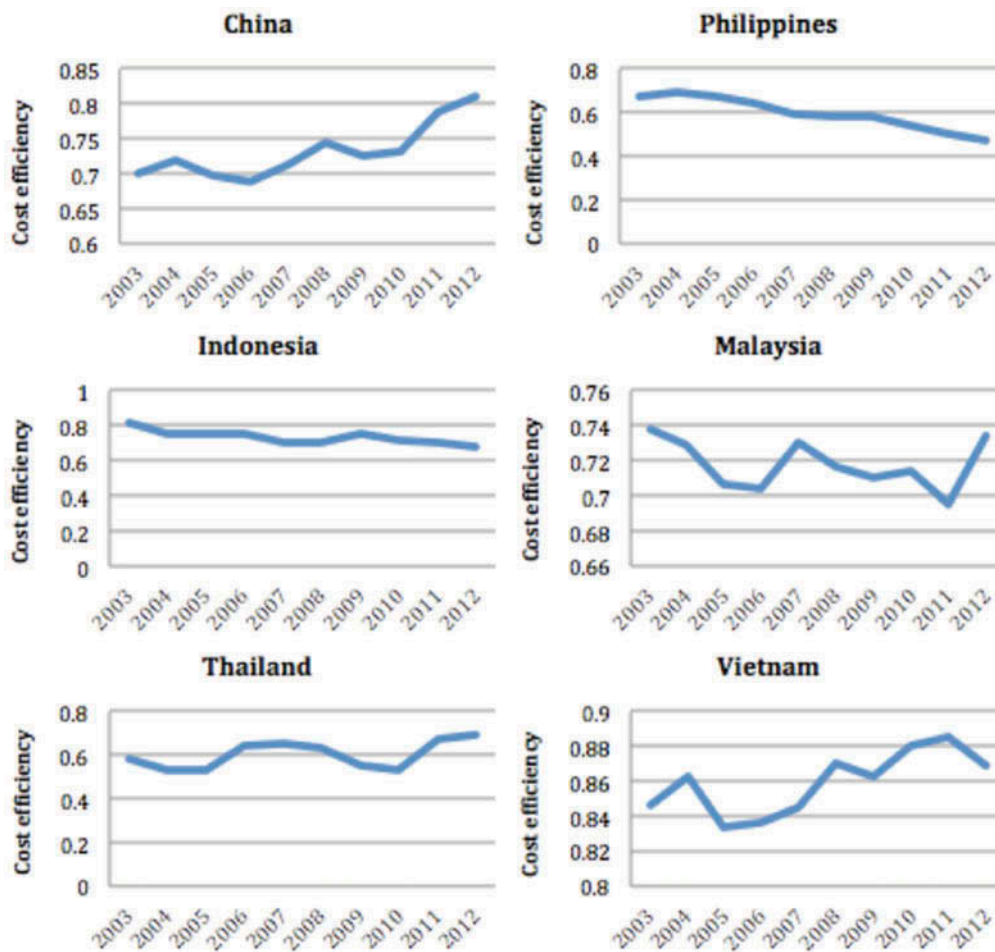
of cost efficiency. It was found that this ratio had a significant negative effect on cost efficiency at the 5% t level, which means that a bank with a higher loan loss reverses ratio will have reduced cost efficiency. A higher ratio of loan loss reverses over gross loan would mean that a bank has a larger possibility of non-performing loans (Sun & Chang, 2011). The results of this study are in-line with the conclusions of most studies on credit risk effect, such as a study of eight Asian emerging countries by Sun and Chang (2011) and studies of developed economies, such as the ones of the European banking system by Pastor (2002) and Fiordelisi et al. (2011); or of the American market, by Berger and DeYoung (1997). This is a reasonable explanation for the depressing effect on cost efficiency of higher credit risk measures. The implication is that the higher loan loss reverses ratio leads to a higher cost of dealing with these non-performing loans and leads to a lower management level (Berger & DeYoung, 1997).

Model 2 in Table 8 illustrates the effects of operational risk measures on bank cost efficiency. In this case, operational risk is measured by ETA ratio and ROAV. The results show that both the ETA ratio and ROAV have significant negative effects on the cost-efficiency scores. The first effect from the ETA ratio, with a negative significance at the 1%, level indicates reduced benefits for banks in this higher ratio. The implication is that a riskier bank operation tends to have a higher efficiency. This also explains why bank managers choose a higher debt ratio to reach a more efficient level of operating.

Previous studies have had inconsistent results regarding capital ratio. While Sun and Chang (2011) found a similar trend to that shown in this study in the relationship between ETA ratio and cost efficiency, other studies conducted in United Arab Emirates, Poland, Turkey and Europe have



Figure 2. Cost efficiency for developed East Asia and Pacific economies over the 2003–2012 period.



come to the opposite conclusions; Havrylchuk (2006) and Isik and Hassan (2002), examining the Polish and Turkish banking systems respectively, found a positive relationship between two variables. In addition, both Rao (2005) and Fiordelisi et al. (2011) defined ETA as a capitalization risk and confirmed that well-capitalized banks have higher quality management. Their results support the Basel recommendations on bank capital adequacy as a standard of controlling operational risk and raise the issue of moral hazard in banking operations. These conflicting conclusions indicate that the ideas of safe operating, moral hazard and cost management are still controversial issues for researchers in the banking field.

With regard to the effect of ROAV, the negative relationship, at the 5% level, means that a bank with higher ROAV has an increased uncertainty in its operations and tends to be less efficient than other banks. This result is in-line with the findings of Berger & Mester (1997) and Sun and Chang (2011), which confirmed that poor bankers might be unfavorable as regards both cost and risk management.

Model 3 in Table 8 shows the relationship between liquidity risk factor and bank cost efficiency. The result indicates that a bank with a lower ratio of cash and due from banks to total assets (i.e. higher liquidity risk) has a higher level of cost efficiency. It confirms the conclusion of risk taking related to ETA ratio in the previous model; that is, the safer banks in terms of liquidity risk tend to be lower in cost efficiency. It is common knowledge that the cost of liquidity is one of the highest costs in an operating bank, because banks have to pay without earning to maintain a high amount of cash and cash equivalent. A study in United Arab Emirates by Rao (2005) found conflicting

**Table 8. Estimation results for the effects of risks on cost efficiency of economies in East Asia and Pacific area over 2003–2012 period**

	Model (1)	Model (2)	Model (3)	Model (4)
<i>Dependent variable—COSTEFF</i>				
<i>Independent variables</i>				
LLRGL	<b>-0.0015**</b>			<b>-0.0013**</b>
ETA		<b>-0.0064***</b>		<b>-0.0064***</b>
ROAV		<b>-0.0029**</b>		<b>-0.0021**</b>
CDTA			<b>-0.0012***</b>	<b>-0.0012***</b>
TOTALASSET	0.1039***	0.1593***	0.1027***	0.1570***
TOTALDEPOSIT	-0.0734***	-0.1408***	-0.0717***	-0.1411***
CPI	0.0024***	0.0023***	0.0025***	0.0025***
IR	0.0158***	0.0153***	0.0155***	0.0154***
REGULATION	0.0207***	0.0237***	-0.0211***	0.0243***
GDP	0.0038	0.0107	0.0045	0.0115
YCRISIS	<b>-0.0394***</b>	<b>-0.0337***</b>	<b>-0.0386***</b>	<b>-0.0342***</b>
DEVLOP	<b>-0.1727***</b>	<b>-0.1531***</b>	<b>-0.1719***</b>	<b>-0.1413**</b>
Year fixed effects	YES	YES	YES	YES
Country fixed effects	YES	YES	YES	YES
Log likelihood	2156.895	2223.0837	2158.2574	2230.5633
Observations	2378	2378	2378	2378

This table reports the results of examining the relationships between three kinds of risk and cost efficiency. Models (1)–(3) examined the separate effects of respectively credit risk, operational risk, and liquidity risk, model (4) examined the total effects of three of risks on cost efficiency that estimated during the period 2003–2012. The measures of risks are LLRGL, ETA, ROAV, CDTA. There are six control variables, including TOTALASSET, TOTALDEPOSIT, CPI, IR, GDPLOG, REGULATION, and two dummy variables, including YCRISIS, DEVLOP.

\* Significant at the 10% level.  
 \*\* Significant at the 5% level.  
 \*\*\* Significant at the 1% level.

evidence on this relationship and concluded that a higher liquidity ratio tended to increase banks' cost efficiency during the observed time. This raises the same issue regarding risky and efficient operations in the banking system, such as ETA ratio analysis, and requires further study.

Model 4 in Table 8 examines the combined effects of all risk variables on cost efficiency simultaneously and provides exactly the same trends as the separate models. Thus, it can be concluded that all kinds of risks have negative effects on banks' cost efficiency. That means a high level of risk factors in all mentioned fields, including credit, operation and liquidity, leads to a low level of cost management.

This study found that the control variables also had significant effects on cost efficiency. Interestingly, all of the control variables had the same effects on cost efficiency across all the models, indicating that multicollinearity was not a concern in this study. Another interesting finding shown in Table 8 is that most of control variables have significant effects at the 1% or 5% level, except for GDP. The reason that GDP has no effect on bank efficiency is that it is unlike the other control variables (e.g. the banks' assets and deposits, inflation, interest, banking system regulation, etc.), which all relate to the banking system operation at both bank and country level.

At the bank level, TOTALASSET and TOTALDEPOSIT had opposite relationships with bank cost efficiencies: TOTALASSET has a positive effect on cost efficiency; TOTALDEPOSIT has a significant negative effect at the 1% level. This could imply that banks that are bigger in terms of total assets are more efficient in cost management. However, banks that are bigger in terms of total deposits

tend to have lower cost efficiency because they deal with a high liquidity ratio and face a high pressure of paying interest expenses. This is additional evidence for the effect of liquidity risk on cost efficiency, as previously mentioned.

At the country level, most of the control variables (except for GDP) have a positive relationship with bank efficiency in terms of cost management. It is difficult to explain this situation when high inflation (represented by CPI) and high IR are reputed to be bad indicators of the economy, especially of the banking sectors. In addition, the ratio of capital requirement (represented by REGULATION) is one of the factors that limit the operation and income of banks. The most reasonable explanation is the intermediary role of banks in the economy. Banks run their business on trading money and the above macroeconomic factors provide materials for their business. This implies that higher ratios of inflation, interest and capital requirements help the banks to get more jobs, earn more income with the same expenses, and then push the cost efficiency upwards. This study's analysis of the environmental variables contributes to the literature on the banking system, with the confirmation of more determinants of bank performance.

Table 9 provides the results of testing the relationships between three kinds of risks and bank cost efficiency across the 12 studied economies in the East Asia and Pacific area. The analysis shows large differences in the relationships. With regard to the effect of credit risk, while there are the negative coefficients in most of economies, Thai banking industry shows a totally different result with positive and significant coefficient on LLRGL (at the 5% level), indicating that a higher credit risk in Thai banks could lead to higher efficiency. Notably, we find the similar trend for Indonesian banks in which the relationship between cost efficiency and operational risk measured by ETA coefficient is positive and statistically significant. For liquidity risk, we find two representatives for this opposite direction which have positive significance at the 5% level, they are New Zealand and Hong Kong. The implication in most of cases that have negative relationship is a bank with high deposit intending to be lower efficient in terms of cost management. This means that these relationships were affected by the context of each economy and, therefore, require further examination to allow comparisons between the countries.

#### **4.2. Further analysis for different groups of economies and different periods**

The results in Table 10 provide further detail about the differences in cost management and risk relations between the two groups of economies in terms of their development level. The results of the four models in the previous section were analyzed, but only the combined models (4a and 4b) are discussed here. For the four measurements of risk (LLRGL, ETA, ROAV and CDTA), the same negative effects were found in both groups of economies. These effects were consistent with the analysis of the full sample in the previous section, which conformed that there were strong relationships between credit risk and operation risk, measured by ETA, whether in a developing or developed banking system. This implies that controlling these risks has a role in managing cost efficiency at all levels of economic development. However, while ROAV and CDTA were still significant factors in developing economies, at the 1% level, they seemed to have no effect on cost efficiency in developed countries.

We now examine the impact of the 2008 GFC on the relation between cost efficiency and risks of separated group of economies in East Asia and Pacific area. Table 11 provides the results of the examination of the full sample, for both developed and developing economies, divided into two periods: pre-crisis and post-crisis. With regard to the full sample, only the effects of LLRGL and ROAV changed from significant in the pre-crisis period to insignificant in the post-crisis period. This could imply that the way banks dealt with the GFC affected their level of cost and risk management and changed these relationships. Further research would be required to confirm this theory. This also applies when dividing the full sample into the two groups of economies. In particular, developed groups seemed to be much more affected by the GFC than the developing group. While LLRGL and CDTA both lost their relationship of significance when changing from before to after the financial crisis,

**Table 9. Estimation results for the effects of risks on cost efficiency across economies in East Asia and Pacific area**

	Developed economies						Developing economies					
	Australia	New Zealand	Hong Kong	Singapore	Japan	Korea	China	Philippines	Indonesia	Malaysia	Thailand	Vietnam
LLRGL	<b>-0.018*</b>	-0.011	-0.021	-0.004	<b>-0.007*</b>	-0.014	<b>-0.008***</b>	-0.002	<b>-0.002**</b>	-0.001	<b>0.003**</b>	0.002
ETA	<b>-0.011***</b>	0.001	-0.001	<b>-0.012***</b>	-0.001	-0.005	<b>-0.009***</b>	<b>-0.009***</b>	<b>0.003*</b>	<b>-0.012***</b>	-0.002	<b>-0.002**</b>
ROAV	<b>0.007*</b>	0.006	-0.009	0.054	0.003	-0.009	-0.028	0.006	-0.001	<b>-0.023**</b>	-0.013	0.013
CDTA	-0.003	<b>0.003**</b>	<b>0.003**</b>	0.001	<b>-0.003*</b>	0.001	-0.001	-0.001	<b>-0.004***</b>	-0.001	<b>-0.004***</b>	<b>-0.002***</b>
TOTALASSET	0.135*	0.187***	0.298	0.462***	0.119	0.101***	0.524***	0.342***	-0.211**	0.060**	0.277*	0.262***
TOTALDEPOSIT	-0.023	-0.188***	-0.288	-0.425***	-0.088	-0.087**	-0.520***	-0.328***	0.247**	-0.054**	-0.225	-0.260***
CPI	-0.003	0.002	0.036***	0.020***	-0.034***	0.001	0.005*	0.005*	-0.003*	-0.001	-0.005	0.001**
IR	-0.001	-0.001	0.031***	0.069***	0.408***	0.006	-0.002	-0.003	0.008*	0.004	0.030***	0.001
REGULATION	0.008	0.000	0.155***	0.057	0.115***	0.051***	0.007	-0.025	0.000	-0.015	0.000	0.000
GDP	<b>-0.384***</b>	-0.069*	-0.167	-0.513***	0.372***	0.001	0.066***	-0.477***	-0.262***	-0.080	0.046***	0.213
Log likelihood	186.0185	107.8355	180.1397	70.2373	627.1776	185.4395	364.1614	223.9751	426.8603	195.9820	185.6297	365.4070
Observations	108	36	175	67	499	160	251	184	337	203	198	159

Note: This table reports the results of examining the relationships between three kinds of risk and cost efficiency (COSTEFF) across economies. We only focus on Model (4) which combines all kinds of risks into one model. The measures of risks are LLRGL, ETA, ROAV, CDTA. There are six control variables, including TOTALASSET, TOTALDEPOSIT, CPI, IR, GDPLOG, REGULATION. The economic development classification follows World Economic Outlook reported by the International Monetary Fund (2012).

\* Significant at the 10% level.

\*\* Significant at the 5% level.

\*\*\* Significant at the 1% level.

**Table 10. Estimation results for the effects of risks on cost efficiency divided by developing and developed economies in East Asia and Pacific area**

	Developing countries				Developed countries			
	Model (1a)	Model (2a)	Model (3a)	Model (4a)	Model (1b)	Model (2b)	Model (3b)	Model (4b)
<i>Dependent variable—COSTEFF</i>								
<i>Independent variables</i>								
LLRGL	-0.0006***			<b>-0.0004***</b>	-0.0203***			<b>-0.0253***</b>
ETA		-0.0062***		<b>-0.0062***</b>		-0.0062***		<b>-0.0081***</b>
ROAV		-0.0034***		<b>-0.0031***</b>		-0.0002		0.0031
CDTA			-0.0009**	<b>-0.0010***</b>			-0.0009	-0.0010
TOTALASSET	0.0787***	0.1341***	0.0767***	0.1319***	0.1144***	0.1828***	0.1231***	0.1899***
TOTALDEPOSIT	-0.0654***	-0.1325***	-0.0637***	-0.1320***	-0.0652**	-0.1400***	-0.0718**	-0.1548***
CPI	0.0015*	0.0015**	0.0015*	0.0016**	0.0080***	0.0069***	0.0080***	0.0069***
IR	0.0124***	0.0119***	0.0122***	0.0120***	0.0439***	0.0355***	0.0364***	0.0325***
REGULATION	0.0005	0.0050	0.0001	0.0059*	0.0740***	0.0692***	0.0695***	0.0755***
GDP	0.0097	0.0156**	0.0099	<b>0.0160**</b>	-0.0399	0.0164	0.0017	<b>-0.0240</b>
Country fixed effects	YES	YES	YES	YES	YES	YES	YES	YES
Log likelihood	1293.4006	1357.4021	1295.4984	1360.9813	974.15341	966.87653	957.96432	991.98627
Observations	1332	1332	1332	1332	1045	1045	1045	1045

Note: This table reports the results of examining the relationships between three kinds of risk and cost efficiency (COSTEFF). Models (1a,b)—(3a,b) examined the separate effects of respectively credit risk, operational risk, and liquidity risk, model (4a,b) examined the total effects of three of risks on cost efficiency that estimated during the period 2003–2012. Series (a) models examined the effects for group of developing countries, and series (b) for the other group—developed countries. The measures of risks are LLRGL, ETA, ROAV, CDTA. There are six control variables, including TOTALASSET, TOTALDEPOSIT, CPI, IR, GDPLOG, REGULATION.

\* Significant at the 10% level.

\*\* Significant at the 5% level.

\*\*\* Significant at the 1% level.

**Table 11. Estimation results for the effects of risks on cost efficiency of economies in East Asia and Pacific area for the pre- and post-global financial crisis 2008**

	Full sample		Developed economies		Developing economies	
	Pre-2008	Post-2008	Pre-2008	Post-2008	Pre-2008	Post-2008
LLRGL	-0.0017***	0.0005	-0.0227***	0.0107	-0.0012	0.0019
ETA	-0.0038***	-0.0034***	-0.0072***	-0.0098***	-0.0045***	-0.0025**
ROAV	-0.0054***	-0.0022	-0.0054	0.0256**	-0.0038	-0.0037***
CDTA	-0.0016***	-0.0011**	-0.0028**	-0.0006	-0.0012**	-0.0011**
TOTALASSET	0.1687***	0.1389***	0.4519***	0.1710***	0.1335***	0.1340***
TOTALDEPOSIT	-0.1541***	-0.1229***	-0.4154***	-0.1460***	-0.1256***	-0.1274***
CPI	-0.0003***	0.0068***	0.0207***	0.0137***	-0.0014	0.0038***
IR	0.0290***	0.0149***	0.0160***	0.0169***	0.0225***	0.0092***
REGULATION	0.0491***	0.02490***	-0.0051	-0.0490	0.0290**	0.0442***
GDP	0.0133***	0.0210***	0.1206***	-0.1108**	-0.0799***	0.0308***
Log likelihood	1091.3593	1257.0114	526.9066	479.9259	660.5120	862.9133
Observations	1153	1153	505	540	648	684

Note: This table reports the results of examining the relationships between three kinds of risk and cost efficiency (COSTEFF) for the separated periods: pre- and post-global financial crisis. We only focus on Model (4) which combines all kinds of risks into one model. The measures of risks are LLRGL, ETA, ROAV, CDTA. There are six control variables, including TOTALASSET, TOTALDEPOSIT, CPI, IR, GDPLOG, REGULATION.

\* Significant at the 10% level.  
 \*\* Significant at the 5% level.  
 \*\*\* Significant at the 1% level.

ROAV had a significant effect on cost efficiency for the whole 2008–2012 period. ROAV was also the only risk factor with a changed relationship in both the developed group and developing group.

#### 4.3. Robustness test: testing for endogeneity

To alleviate the potential dynamic endogeneity inherent in the bank risks–efficiency relationship, we carry out the Durbin–Wu–Hausman test (Davidson & MacKinnon, 1993) as our robustness check. According to Sun and Chang (2011), since both risk-taking behavior and efficiency are simultaneously determined in a banking system in which efficient goal is a component, changes in risk behavior should not be systematically related to changes in bank efficiency. If bank risk variables are endogenously determined, the regression model may be mis-specified. In other words, bank risks should be unrelated to financial performance in terms of cost efficiency in the presence of endogeneity sourced from simultaneity and unobserved heterogeneity (Sun & Chang, 2011). The Durbin–Wu–Hausman test is performed to justify the use of the two-stage least squares method (2SLS). First, a “suspicious” endogenous variable (e.g. LLRGL, ETA, ROAV, CDTA) is regressed against all the exogenous variables and instrumental variables and the residuals (i.e., LLRGL\_res) are saved. The two selected instrumental variables are total equity (EQUITY) and ratio of liquid assets to total liabilities (LIQUIDRATIO).<sup>6</sup> For example, the equation for examining the endogeneity of LLRGL is specified as follows:

$$\begin{aligned} LLRGL_{i,c,t} = & \beta_0 + \beta_1 ETA_{i,c,t} + \beta_2 ROAV_{i,c,t} + \beta_3 CDTA_{i,c,t} + \beta_4 EQUITY_{i,c,t} \\ & + \beta_5 LIQUIDRATIO_{i,c,t} + \alpha' Bank\ Controls_{i,c,t} + \gamma Bank\ Regulation\ Control_{c,t} \\ & + \rho' Macro\ Controls_{c,t} + Year\ Dummies + Country\ Dummies + e_{i,c,t} \end{aligned}$$

Second, the residuals of the endogenous variable (LLRGL\_res) obtained from first stage are added as an additional independent variable in the following equation:

$$\begin{aligned} COSTEFF_{i,c,t} = & \beta_0 + \beta_1 LLRGL_{i,c,t} + \beta_2 ETA_{i,c,t} + \beta_3 ROAV_{i,c,t} + \beta_4 CDTA_{i,c,t} \\ & + \beta_5 LLRGL\_res_{i,c,t} + \alpha' Bank\ Controls_{i,c,t} + \gamma Bank\ Regulation\ Control_{c,t} \\ & + \rho' Macro\ Controls_{c,t} + Year\ Dummies + Country\ Dummies + e_{i,c,t} \end{aligned}$$

If the coefficient of LLRGL\_res is statistically significant, the regression result obtained from Equation (4) will be inconsistent and biased. Therefore, 2SLS is justified and should be applied to SFA. As shown in Table 12, the DWH test results show that coefficients of residuals of bank risk variables are not statistically significant, suggesting that all risk type variables are exogenous and thus endogeneity is unlikely to be a problem.

#### 5. Conclusion

This study adds to the banking literature a research on risks and environmental factors in the relationships with bank cost efficiency through the view of comparisons between developing and developed economies in a specific geographic area. We collected an unbalanced panel data of 247 banks in 12 developed and developing economies in East Asia and Pacific region, including Australia, Hong Kong, Japan, Korea, New Zealand, Singapore; and China, Indonesia, Malaysia, Philippines, Thailand, Vietnam,

**Table 12. Results of testing for endogeneity**

	F-test statistics	p-value	Decision
LLRGL_res	8.68	0.602	Not endogeneity
ETA_res	16.48	0.403	Not endogeneity
ROAV_res	4.89	0.214	Not endogeneity
CDTA_res	16.59	0.901	Not endogeneity

Note: LLRGL\_res is the residual of LLRGL. ETA\_res is the residual of ETA. ROAV\_res is the residual of LROAV. CDTA\_res is the residual of CDTA. This table reports results of the Durbin–Wu–Hausman tests. The residual value of every independent variable is obtained from the first procedure of the mentioned tests, and then used in the second procedure to test for endogeneity.

during the period of 2003–2012. We employed SFA to estimate efficiency and to examine the effects of credit, operational, liquidity risk and environmental factors on bank efficiency over the period both pre- and post-global financial crisis in 2008.

First, we found that the overall average of efficiency scores indicate that the observed banks could have produced their outputs using 62% of their actually spent inputs. It is not a high score in comparison with previous studies on the area having the same level of development. We also have a surprising result when comparing scores between groups of economies when efficiency scores' mean of developing countries is much higher than developed countries' one, even 20% higher. In detail, mean of developing countries is around 70% in comparison with only 51% of the other group.

Second, we found the significant negative effects of three kinds of risk, including credit risk, operation risk and liquidity risk, on banks efficiency. However, there are different levels of the significant effects among developed and developing economies. The finding also confirms that the environmental factors have significant effect on banking system when most of control variables have significant effects at 1% or 5% level, but GDP. We also found that there are the different effects of risks on bank cost efficiency between developing and developed economies, and between period pre- and post-GFC.

With regard to the environmental factors studied, there was evidence that most of the control variables relating to the economic environment, such as inflation, market interest rate and capital requirement, have positive significant effects on banks' cost efficiency. The analysis of the environmental variables that was conducted in this study contributes to the literature, with the confirmation of more determinants of bank performance. It also indicates that policy makers need to ensure that their countries' economies are in a mature and stable situation, to boost the level of efficiency of the commercial banks. This is crucial, because the banking industry serves as the main channel for monetary policy transmission in the developing countries.

There were some limitations in this study that give rise to further research opportunities in this field. First, this study applied only SFA to estimate efficiency scores. An alternative approach could employ DEA to estimate efficiency or apply both SFA and DEA to the same data set to achieve a compared result and a deeper finding in measuring cost efficiency. Second, when measuring banks efficiency functions, there are three points of view that can affect the efficiency scores: cost efficiency (selected for this study), profit efficiency and production efficiency. Future study applying all three functions in estimating efficiency scores for the same data set would achieve deeper findings and stronger recommendations for both bankers and regulators. Although 12 observed economies in the East Asia and Pacific area is a large enough sample to have representatives in all levels of economic development, a future study with the same methodology could expand its sample to regions throughout the world, thus providing a “big picture” in the field of efficiency and risk, as well as an overview of the world's banking systems, especially for the 5 years since the 2008 GFC

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#### Notes

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2. These are explained further in the next section.
3. The highest number of selected banks was in Japan, with 50 banks.
4. SFA—sometimes also referred to as the econometric frontier approach—employs a composed error model



- in which inefficiencies are assumed to follow an asymmetric distribution, usually the half-normal, while random errors follow a symmetric distribution, usually the standard normal (Berger & Humphrey, 1997).
- We follow recent cross-country studies (e.g. Doan, Lin, & Doong, 2018; Lin, Doan, & Doong, 2016) that account for differences arising from country-specific aspects of regulatory conditions, financial freedom, credit information and other macroeconomic conditions by including the indicators of these environmental factors in a more comprehensive definition of a common frontier.
  - The instrumental variables are inspired by Sun and Chang (2011).

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## Appendix

Let us estimate efficiency levels by specifying the common translog functional form, which results in the following empirical cost frontier:

$$\ln TOTALCOST_j = \alpha + \sum_{rj} \beta_r \ln Y_{rj} + \sum_{ij} \beta_i \ln P_{ij} + \frac{1}{2} \sum_i \sum_k \beta_{ik} \ln Y_{ij} \ln Y_{kj} + \frac{1}{2} \sum_i \sum_z \beta_{iz} \ln P_{ij} \ln P_{zj} + \sum_r \sum_i \beta_i \ln Y_r \ln P_i + \ln v_i + \ln u_j$$

where *TOTALCOST* is the bank's total costs in a given year; *Y<sub>r</sub>* are outputs; *P<sub>i</sub>* are input prices; and  $\alpha$  and  $\beta$  are the parameters to be estimated. The translog cost function is estimated using  $\ln v_i + \ln u_j$  as a composite error term. Using the same procedure employed by Jiang, Yao, and Feng (2013), we also normalize total costs and output variables by total assets to control for scale biases and heteroskedasticity.

We use the intermediation approach to classify the outputs and input prices of the banking industry. Regarding the intermediation approach, banks are considered financial intermediaries that take deposits from savers and make loans to economic agents who require capital (Allen & Santomero, 1997). Following Bonin et al. (2005) and Berger et al. (2009), we choose the following four outputs: total loans (TOTALLOAN), other earning assets (OEASSET), total deposits (TOTALDEPOSIT) and liquid assets (LIQUIDASSET). Furthermore, widely consistent with previous studies on bank efficiency, we use the following two input prices: the price of funds (PFUND), measured by the ratio of interest expenses to total deposits, and the price of capital (PCAPITAL), defined by the ratio of non-interest expenses to total fixed assets. The total costs of banks are calculated by the summation of total of interest expenses and non-interest expenses. We also follow Jiang et al. (2013) to impose linear homogeneity restrictions by normalizing by using the price of funds.



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