

Study of Hong Kong Banking System

Hien Thu Phan¹, Hanh Thi My Phan², Kevin Daly^{3*}

¹*School of Banking, University of Economics Ho Chi Min City, Vietnam*

²*Faculty of Finance and Banking, University of Finance - Marketing, Vietnam*

³*School of Business, University of Western Sydney, Australia*

**Corresponding Author: Kevin Daly, school of Business, University of Western Sydney, Australia, Email: k.daly@westernsydney.edu.au*

ABSTRACT

This paper investigates bank cost efficiency and analyses the relationships between competition, stability, and efficiency in the Hong Kong banking system over the period 2004 – 2014. The study employs various approaches to measure bank efficiency, bank competition and bank stability for the robustness checks of the results. Our findings suggest that bank competition is negatively related to cost efficiency whereas bank stability (measured by Z-score ROAA) has a positive impact on cost efficiency. By contrast, effects of bank stability (measured by Z-score ROAE) and credit risk on bank efficiency may be positive or negative when considering efficiency measured by different approaches. The bank size, listing status of banks, macroeconomic environments (including gross domestic product (GDP) growth, inflation, and global financial crisis) have positive effects on cost efficiency. On the contrary, revenue diversification and liquidity risk contribute to decreases in cost efficiency in this banking sector.

Keywords: Bank efficiency; stability; competition; Stochastic frontier analysis; Data Envelopment Analysis

JEL Codes: C2, G2

INTRODUCTION

Traditionally Hong Kong has been acknowledged globally as having a strong, independent and stable banking system, in addition the Hong Kong dollar has over time been recognized as a stable managed currency, the Hong Kong economic model is viewed by foreigners as somewhat more liberal than that of mainland China, in addition Hong Kong administers a lower taxation regime relative to most developed economies, taken together these characteristics make Hong Kong an attractive financial investment destination for multinational banks (Zhang and Daly, 2012). The dramatic development of Hong Kong's financial sector has provided good conditions for operations of big banks in the world in recent years. In 2014, there were around 70 of the biggest 100 banks in the world, 202 authorised institutions and 61 representative offices operating in Hong Kong. The high concentration levels of international banking institutions may result in an increased competition in the banking sector. As a result, Hong Kong's financial services industry is ranked second and third in the list of countries that have a highly competitive financial services industry following the IMD's World

Competitiveness Yearbook and the Global Financial Centers Index, respectively. In the highly competitive environment, bank efficiency has raised concern to improve the performance, management quality and strength of banks. Efficiency analysis is also a way to move banks toward a best practice frontier (Berger et al., 2009). However, only limited studies have examined bank efficiency in Hong Kong. For instance, Kwan (2006) estimated X-efficiency using the Stochastic Frontier Analysis(SFA) approach whereas Drake et al. (2006) investigated technical efficiency using the two-stage Data Envelopment Analysis(DEA) approach. Both studies used data set of the Hong Kong banking sector before 2001.

Hence, it seems to be lack of the latest empirical evidence on efficiency of the Hong Kong banking system, especially over the period of the global financial crisis. Therefore, this paper attempts to fill a demanding gap in the literature by investigating the cost efficiency of the Hong Kong banking sector during the period 2004 to 2014 capturing the effect of the global crisis on efficiency. Additionally, unlike prior studies on bank efficiency in Hong Kong, the study measured bank efficiency using both parametric

and non-parametric approaches for robustness checks of the result and developed various models to investigate the relationship between bank competition, bank stability and bank efficiency in this economy over this period.

This study brings four main contributions. First, it examined cost efficiency of banks in Hong Kong during the period of 2004 – 2014 covering the recent global financial crisis using both SFA and DEA window analysis. Second, the research tested various research models to examine the relationship between bank competition, stability and efficiency in Hong Kong banking over this period.

Third, the academic literature on the relationship between efficiency and stability in the banking industry is still in its infancy. Unlike the majority of previous studies considered the correlation between efficiency and risk (Kwan and Eisenbeis, 1997, Berger and DeYoung, 1997, Hughes and Moon, 1995, Hughes and Mester, 1998, Williams, 2004, Altunbas et al., 2007, Fiordelisi et al., 2011, Zhang et al., 2013), this study investigated the relationship between bank efficiency and bank stability using a direct measure of stability, thus it is not necessary to assume that banks with less risk may have higher stability. Fourth, many robustness checks of the results are conducted by considering different approaches for measuring bank efficiency (SFA and DEA), bank stability ($Z\text{-score}_{ROAA}$ and $Z\text{-score}_{ROAE}$), and bank competition (the conventional Lerner and efficiency-adjusted Lerner) and using different research models.

The findings indicate that bank competition is negatively related to cost efficiency whereas bank stability (measured by $Z\text{-score}_{ROAA}$) has a positive impact on cost efficiency. By contrast, effects of bank stability (measured by $Z\text{-score}_{ROAE}$) and credit risk on bank efficiency may be positive or negative when considering efficiency measured by different approaches. The bank size, listing status, and macroeconomic environments such as GDP growth, inflation, and global financial crisis have positive impacts on bank cost efficiency. Revenue diversification and liquidity risk contribute to a decrease in cost efficiency in Hong Kong's banking sector.

The paper is organised as follows: section 2 reviews the brief literature on bank competition, bank stability and bank efficiency, section 3 discusses the data and methodology, section 4 presents results of the relationships between bank competition, bank stability and bank

efficiency in 8 research models. Finally section 5 provides a conclusion.

LITERATURE REVIEW

Bank Competition and Bank Efficiency

The pioneering study of Hicks (1935) supporting greater competition suggested “The best of all monopoly profits is the quiet life” (Hicks, 1935, p. 8). Another research by Berger and Hannan (1998) found that bank managers can exercise market power of banks to gain supernormal profits, however, they have less incentive to maximise their bank efficiency in a “quiet life”. Thus, banks exposed to greater competition tend to be more efficient than those which are less competitive. By contrast, the Information Generation Hypothesis (IGH) (Marquez, 2002) theorises on a negative relationship between competition and efficiency. This hypothesis is based on the view that banks are “special” intermediaries because they can access borrowers' information to collect and analyse inside information, and thus they are able to reduce their adverse borrower selection to a minimum level, due to the ability to generate superior information compared to their peers. However, in growing competitive markets, each bank owns specific information about a small pool of borrowers, so this dispersion of information can cause a decline in banks' screening capabilities, increasing the chance of having loans for low-quality borrowers, and thus increasing bank inefficiency. Moreover, when competition increases, banks will offer customers lower charges to attract them. This may lead to easier switches of customers from their current bank to another bank that provides them with more benefits. Therefore, a reduction in a bank's information-gathering capacity due to customer switches also causes bank inefficiency.

The majority of literature on the relationship between bank competition and bank efficiency focuses on the US and European banking. Koetter et al. (2008) tested two competing hypotheses, the quiet life hypothesis (QLH) and IGH, for US banks over the period 1986– 2006 using direct measures of competition including the conventional and the efficiency-adjusted Lerner. They found a significantly negative effect of competition on cost efficiency and profit efficiency, which argues against the QLH. However, increasing market power precedes increasing efficiency, which implies that US banks under low competitive pressure have superior capabilities to screen their borrowers,

thus supporting indirectly the IGH. Also using the sample of the US banking, Koetter et al. (2012) examined the relationships between competition and bank efficiency under historic geographic deregulation and investigated the effect of liberalized banking markets on this relationship over the period 1976– 2007. The authors found a negative effect of competition on cost efficiency, thus rejecting the QLH. However, the QLH is supported when considering profit efficiency because market power, measured by the efficiency-adjusted Lerner index, is negatively related to profit efficiency.

Maudos and De Guevara (2007) examined the relationship between bank efficiency and bank competition in 15 EU countries (EU-15) during 1993 – 2002. They found that bank competition is a significantly negative determinant of cost efficiency. Several reasons are proposed to explain their result. First, the monopolistic power of banks due to their location advantages decreases their cost of monitoring and transacting with companies. Second, banks may have cost advantages in screening borrowers due to market power obtained from geographical and technological specialization. Third, banks with market power may enjoy higher profit so they behave prudently and select less risky activities to lower the cost of monitoring, thus increasing their cost efficiency. Fourth, greater market power allows banks to decrease their operating costs because of less pressure to enhance the quality of banking services, thereby improving their cost efficiency. Casu and Girardone (2009) investigated whether competition leads to cost efficiency using the Granger causality test for the sample of European banks over the period 2000– 05. The authors found that a positive causality runs from market power, proxied by the Lerner index, to cost efficiency measured by both SFA and DEA approaches, possibly because banks with higher market power enjoy lower financial and operating costs. The influence of monopoly power on efficiency may be positive if this power makes banks lower their costs. Moreover, Granger causality tests can only show that an increase in market power precedes an increase in efficiency, rather than establishing causality between these variables. Therefore, in line with results reported by Maudos and De Guevara (2007), Casu and Girardone (2009) suggested that a positive relationship between market power and efficiency is not necessarily informative about

their causal relationship. The authors also examined the causality running from efficiency to competition. Granger causality tests, however, provide no proof that increases in efficiency forego increases in market power. As a result, they agreed with findings of Casu and Girardone (2006) that the relationships between competition and efficiency are not straight forward. Schaeck and Čihák (2008) used Granger causality tests to examine the influence of competition on bank efficiency, reporting a positive influence of competition on profit efficiency for a large sample of European and US banks during 1995– 2005. Additionally, the findings for the US sample show that competition increases cost efficiency. On this basis, Schaeck and Čihák (2008) suggested that banks can attain higher efficiency levels in both cost and profit under competitive pressure. Delis and Tsionas (2009) found a negative relationship between market power and efficiency in the Economic and Monetary Union banking system by establishing a framework for the joint estimation of market power and efficiency.

Recent studies of banking have investigated the relationships between competition and efficiency in developing countries. Chen (2009) Proposed that a higher degree of bank competition pushed cost efficiency in Sub-Saharan African countries over the 2000 – 2007 period. Pruteanu-podpiera et al. (2008) examined the relationship and causality between bank competition and bank cost X-efficiency using data on Czech banks over the transition period of 1994 – 2005. Their findings indicate that greater competition reduces cost efficiency in banking due to a rise in monitoring cost and the appearance of economies of scale. Indeed, the result of Granger causality test favors a negative causality from competition to efficiency of Czech banks over the transition period. Also investigating the determinants of bank efficiency in the context of transition economies, Fang et al. (2011) reported a positive association between market power and efficiency, including both cost and profit efficiency, in banking systems across six transition countries of South-eastern Europe during 1998– 2008. Williams (2012) investigated the relationship between market power and efficiency of Latin American banks in different markets (loan, deposit and assets markets) during the 1985– 2010 period and two sub periods including the pre-restructuring (1985 – 1997) and post-restructuring (1998 –

2010) periods. The author found reveal significant positive associations between market power and efficiency in the assets market; however, Latin American banks seem to enjoy a “quiet life” in the deposits market in each sub-period and the full period. Kasman and Carvalho (2014) also provided a strong evidence to support the “quiet life” hypothesis for commercial banks in 15 Latin American countries over the period 2001 – 2008 using the

Bank Stability and Bank Efficiency

The academic literature on the relationship between efficiency and stability in the banking industry is still in its infancy. Very few studies have investigated this relationship using a direct measure of stability such as Z-score. Instead, they considered the correlation between efficiency (or performance) and risk. Their findings may propose the relationship between bank stability and bank efficiency with an assumption that banks with less risk may have higher stability.

Prior studies on the US banking sector suggested that inefficiency has a positive impact on risk taking (Kwan and Eisenbeis, 1997, Berger and DeYoung, 1997, Hughes and Moon, 1995, Hughes and Mester, 1998). Additionally, investigating the relationship between efficiency and risk in the European banking by applying the Granger causality approach, Williams (2004) and Fiordelisi et al. (2011) suggested that less efficient banks may take higher risk. On the other hand, Altunbas et al. (2007) argued that efficient banks have a tendency to hold less capital and take more risk in Europe.

Lin et al. (2005) found a negative relationship between insolvency risk and financial performance in the Taiwan’s banking system over 1993 - 2000. By contrast, findings by Tan and Floros (2013) indicated a significantly positive correlation between efficiency and risk in the Chinese banking. Their study indicated that Z-score and efficiency are negative related but this finding is insignificant. Zhang et al. (2013) investigated the effects of market concentration and risk-taking on technical efficiency for a group of emerging countries including Brazil, China, India and Russia. They suggested that efficiency is positively impacted by credit risk, market risk, and overall risk but negatively impacted by liquidity risk. By using the Granger causality technique to examine dynamic relationships between financial stability (measured by Z-scores) and both cost and revenue efficiency, Kasman and Carvalho

Granger causality technique to examine dynamic relationships between bank competition (measured by Lerner indices and Boon indicators) and both cost and revenue efficiency. Turk Ariss (2010) provided evidence for a negative (positive) relationship between market power and cost efficiency (profit efficiency) in developing countries over 1999 – 2005.

(2014) suggested that there is insignificant relationship between financial stability and efficiency of commercial banks in 15 Latin American countries over the period 2001 – 2008.

DATA AND METHODOLOGY

Estimation Methodology: Bank Efficiency, Bank Competition and Bank Stability

Bank Efficiency

One of factors representing the quality of bank management is bank efficiency (Maudos and De Guevara, 2007, Williams, 2012). A bank’s cost efficiency is calculated as the ratio of a bank’s estimated minimum cost to produce a certain output to the actual cost of production (Coelli et al., 2005, Berger and Mester, 1997). Two widely used approaches to measure bank efficiency including parametric and non-parametric approaches that estimate the frontiers by econometric techniques and linear programming techniques, respectively.

Firstly, this study measured cost efficiency using the Stochastic Frontier Analysis (SFA), a commonly used parametric approach, which introduced simultaneously by Aigner et al. (1977) and Meeusen and Van Den Broeck (1977). Then, Data Envelopment Analysis (DEA), a non-parametric approach first developed by Charnes et al. (1978), was used to estimate cost efficiency for the robustness checks of the results. This method is a linear programming technique which estimates best-practice frontiers by observing management practices in the research sample.

The stochastic frontier approach assumes that the error term (ε) or disturbance term contains two components: a two-sided random error term (ν) capturing the effects of random noise and a non-negative inefficiency score (u) capturing inefficiency relative to the frontier. This study used the SFA model of Battese and Coelli (1995) that allows to analyze the effects of environmental variables (E) on inefficiency in order to explain the differences in the

inefficiency effects among banks. In this model, the components of error terms are distributed independently; v_{it} is assumed to be independent and identically distributed with mean zero and variance σ_v^2 as a normal distribution, $N(0, \sigma_v^2)$, u

Using SFA, cost efficiency scores are estimated from the translog functional form:

$$\begin{aligned} \ln TC / w_3 = & \alpha_0 + \sum_{i=1}^2 \alpha_i \ln y_i + \sum_{i=1}^2 \beta_i \ln(w_i / w_3) + \sum_{i=1}^2 \gamma_i \ln z_i + \delta_1 Trend + \frac{1}{2} \sum_{i=1}^2 \sum_{j=1}^2 \varepsilon_{ij} \ln y_i \ln y_j \\ & + \frac{1}{2} \sum_{i=1}^2 \sum_{j=1}^2 \theta_{ij} \ln(w_i / w_3) \ln(w_j / w_3) + \frac{1}{2} \sum_{i=1}^2 \sum_{j=1}^2 \omega_{ij} \ln z_i \ln z_j + \frac{1}{2} \delta_2 Trend^2 \\ & + \sum_{i=1}^2 \sum_{j=1}^2 \varrho_{ij} \ln y_i \ln(w_j / w_3) + \sum_{i=1}^2 \sum_{j=1}^2 \mu_{ij} \ln y_i \ln z_j + \sum_{i=1}^2 \rho_i \ln y_i Trend \\ & + \sum_{i=1}^2 \sum_{j=1}^2 \sigma_{ij} \ln(w_i / w_3) \ln z_j + \sum_{i=1}^2 \varphi_i \ln(w_i / w_3) Trend + \sum_{i=1}^2 \partial_i \ln z_i Trend + u + v \end{aligned} \tag{1}$$

Both inputs and outputs of banks are specified in this study based on the intermediation approach that considers banks as financial intermediaries that produce the quantity of outputs (y_i) by using inputs (x_i) at given prices (w_i) in order to minimize total costs (TC) (Sealey and Lindley, 1977). Total cost is expressed as a function of two outputs (y_i), three input prices (w_i), two fixed net puts (z_i) and technical change (trend). Time trend variables take into account technical change that considers changes in the cost function over time. Fixed net puts and time trend are used as control variables to account for heterogeneity across banks. Total costs and input prices scaled by the price of labour (w_3)¹ to correct for heteroskedasticity.

Where: total assets and total loans are used as output quantities (y_i). Three input prices (w_i) include the price of deposits (w_1), the price of physical capital (w_2), and the price of labour (w_3). Control variables contain fixed net puts (z_i) (including fixed assets (z_1) and the total equity (z_2)) and the time trend (Trend)² to consider the heterogeneity. The time trend is a proxy for a technical change in the banking

follows a non-negative truncated distribution with mean $\mu = E\delta$ and variance σ_u^2 , that is, $u \sim \text{iid } N^+(\mu, \sigma_u^2)$. The error term (ε) equals the sum of the random error term (v) and the non-negative inefficiency score (u).

system. The error terms (ε) are separated into the random error (v) and the inefficiency (u) in the functional form of the frontier, thus they capture impacts of the statistical noise and the inefficiency. ε_{kt} equals $v_{kt} + u_{kt}$ where v is a symmetric error that includes both the possibility of luck and measurement errors to account for the statistic noise; u is a non-negative random disturbance term that represents the cost inefficiency score. Environmental variables (E) to explain the differences in the inefficiency effects are the listing status, market share and Herfindahl- hirschman index (HHI). Some conditions are suggested for the translog cost function that is linearly homogeneous in input price:

$$\begin{aligned} \sum_{i=1}^3 \beta_i = 1; \quad \sum_{i=1}^3 \theta_{ij} = 0; \quad \sum_{i=1}^3 \varrho_i = 0; \\ \sum_{i=1}^3 \sigma_i = 0; \quad \sum_{i=1}^3 \varphi_i = 0 \end{aligned}$$

By symmetry of the Hessian: $\varepsilon_{ij} = \varepsilon_{ji}$; $\theta_{ij} = \theta_{ji}$; $\omega_{ij} = \omega_{ji}$

Based on the definition above, the cost-efficiency score (CE) is calculated as:

$$CE_k = \frac{\exp[\hat{f}(w_k, y_k, z_k, v_k)]}{\exp[\hat{f}(w_k, y_k, z_k, v_k)] \times \exp(\hat{u}_k)} = \exp(-\hat{u}_k) \tag{2}$$

For a robustness check of the result of cost efficiency, the study estimates cost efficiency of individual banks in the Hong Kong banking using DEA Window Analysis.

The DEA-CCR model, originally proposed by Charnes et al. (1978), is based on the constant

¹The appropriate formula of the labour price is the ratio of personnel expenses to the number of employees. Employee data, however, are not provided sufficiently in our dataset; following to Maudos and De Guevara (2007), the ratio of personnel expenses to total assets are used as an alternative proxy for the price of labour in this study.

²In our sample, the time trend variables take values from 1 to 11 corresponding to the years from 2004 to 2014.

returns to scale (CRS) assumption that is only appropriate when all banks in the analysis sample are operating at their optimal scales. Later, Banker et al. (1984) extended the DEA-CCR model by the assumption of variable returns to scale (VRS), called the DEA-BCC model. Because the CRS assumption may not hold in a wide practice, the DEA-BCC model seems to be more appropriate than the DEA-CCR model to estimate efficiency. Following Banker et al. (1984) and Fare et al. (1985), the study uses the VRS cost minimization DEA model for calculating cost efficiency (CE) as follows:

$$\begin{aligned} & \min_{z, x_i} w_{i0} x_{i0}^* \\ & \text{Subject to} \\ & \sum_{k=1}^K z_k y_{jk} - y_{j0} \geq 0, \quad j = 1, 2, \dots, m \\ & \sum_{k=1}^K z_k x_{ik} - x_{i0}^* \leq 0, \quad i = 1, 2, \dots, n \\ & \sum_{k=1}^K z_k = 1 \\ & z_k \geq 0, \quad k = 1, 2, \dots, K \end{aligned} \quad (3)$$

Where:

k: the number of the bank of each country (k = 1, ..., K)

x_{ik} : i^{th} input of bank k (i = 1, ..., n)

x_{i0}^* : The cost minimizing vector of input quantities for the evaluated bank

w_{i0} : A vector of the given input prices

w_{ik} : i^{th} input price of k^{th} bank

y_{j0} : Given the vector output levels

z: the intensity vector

Cost efficiency is defined as the ratio of a bank's estimated minimum cost to produce a certain output to the actual cost of production (Berger and Mester, 1997, Coelli et al., 2005). Therefore, the cost efficiency (CE) of the k^{th} bank is the ratio of the minimum cost to the actual cost or observed cost:

$$CE_k = \frac{\sum_{i=1}^n w_{ik} x_{ik}^*}{\sum_{i=1}^n w_{ik} x_{ik}} \quad (4)$$

As for the DEA approach, the annual efficiency scores of individual banks in a panel dataset can be estimated by establishing one best-practice frontier for all banks throughout the whole analysis period. In this case, the production technology is assumed to remain unchanged during the research period; however, this assumption is difficult to hold over time. Another method which accounts for the impact of production-technology changes over years is DEA Window Analysis which can be applied to assess the cost efficiency of each decision making unit (DMU) yearly.

The study uses DEA Window Analysis to measure the annual efficiency of individual banks and the banking system of Hong Kong in the analytical sample. The width of the window is 3 years so banks are compared to other banks in a three-year time period, and thus there are 9 windows over the period of 2004 to 2014³. A 3-year window is reasonable because it helps to reduce the unequal comparison among banks over time, however, constitute a sufficient sample size.

To estimate the annual average efficiency scores of individual banks and the whole banking system, the weighted average was used instead of simple average. The weight of each bank for each year is based on total asset criterion. In other words, the weight of an individual bank is the ratio of total assets of each bank to total assets of the whole sample.

Table 1 describes variables that are used to estimate bank efficiency following the DEA and SFA approaches.

Unlike the traditional industrial organization approach that imposes the assumption of the competition-concentration trade-off and implies competition based on concentration, the Lerner Index provides a better and more direct proxy of competitive behavior (Weill, 2013). Whereas the Panzar- Rosse revenue test and the conduct parameter approach assess the degree of competition at the country level, the Lerner index is a proxy for competition at the individual bank level and across time (Angelini

³The first window includes the first three years over the research period. The remaining windows are formed by excluding the first year in the former window and including the following year. For example, the first window covers 3 years of 2004–2006, the second window is from 2005 to 2007 and the period of 2012 to 2014 is for the last window.

and Cetorelli, 2003, Coccorese and Pellicchia, 2010, Maudos and De Guevara, 2007).

Table 1. Variable Descriptions to Measure Cost Efficiency.

Symbol	Variable names	Description
TC	Total cost	Total operating expense
Outputs:		
y ₁	Total earning assets	The sum of total securities and other investments
y ₂	Total loans	Total loans
Inputs:		
x ₁	Total deposits	Total deposits, money market and short-term borrowings
x ₂	Total physical capital	Fixed assets
x ₃	Labour	Personnel expenses
Input prices:		
w ₁	Price of deposits	The ratio of interest expenses to total deposits, money market and short-term borrowings
w ₃	Price of physical capital	The ratio of other operating cost to fixed assets
w ₂	Price of labour	The ratio of personnel expenses to total assets
Control variables		
z ₁	Fixed assets	Fixed assets
z ₂	Total equity	Total equity
Trend	Technical change	Take values from 1 to 11 corresponding to the years from 2004 to 2014

Bank Competition

Therefore, Lerner index method is more suitable for our research model to examine the relationship between bank competition and bank efficiency. Moreover, consistent with studies by Turk Ariss (2010), Koetter et al. (2008, 2012) and Williams (2012), the competition at bank level was estimated here using the Lerner index approach. Lerner indices reflect the degree of market power; therefore, the higher the Lerner index value, the lower the degree of competition.

First, the conventional Lerner index was calculated to measure competition levels of banks with the implicit assumption that banks are fully efficient. However, endogeneity bias can appear in estimates of bank competition if both competition level and efficiency are not derived from a single structural model. Therefore, for the robustness check of the results for competition levels and to account for the interrelationship between competition and efficiency, the efficiency-adjusted Lerner index was employed. The conventional Lerner index was calculated as:

The Lerner index (L) formula is given as:

$$L_{kt} = \frac{P_{kt} - MC_{kt}}{P_{kt}} \tag{5}$$

Here, price (P_{kt}) is defined as average revenue of kth bank at time t, which is measured as the ratio of total revenue to total assets, whereas total revenue equals sum of total profits (TP) and total costs (TC). Marginal cost (MC) is derived

from the translog cost function. Following De Guevara et al. (2005) and Turk Ariss (2010), total cost is expressed as a function of single output (y: total assets), three input prices (w_i), two fixed net puts (z_i) and technical change (trend)⁴ as follows:

The conventional Lerner index can provide a biased measure of competitive behaviour when either of the two components, the price and the marginal cost, is measured inaccurately and under the tacit assumption of full bank efficiency that is difficult to hold (Koetter et al., 2008, 2012).

Unlike the conventional Lerner index, the efficiency-adjusted Lerner index can account for endogeneity bias via simultaneous estimation of both market power degree and efficiency from a single structural model. To consider possible cost inefficiencies of banks, frontier estimates of TC (\widehat{TC}) and TP (\widehat{TP}) were calculated using the model of Battese and Coelli (1995).

Here: y is total assets. Frontier estimates of total cost (\widehat{TC}) and marginal cost (\widehat{MC}) are derived from the translog cost function (see equation (6)). Frontier estimates of total profit (\widehat{TP}) are estimated from the alternative profit function that is similar to the cost function in equation (6), however, TC is replaced by TP as the dependent variable and the error term (ε) being equal to v - u.

⁴Three input prices (w_i), two fixed netputs (z_i) and technical change (trend) are defined in table 1.

$$\begin{aligned}
 \ln TC = & \alpha_0 + \alpha_1 \ln y + \sum_{i=1}^3 \beta_i \ln w_i + \sum_{i=1}^2 \gamma_i \ln z_i + \delta_1 Trend + \frac{1}{2} \alpha_2 (\ln y)^2 \\
 & + \frac{1}{2} \sum_{i=1}^3 \sum_{j=1}^3 \theta_{ij} \ln w_i \ln w_j + \frac{1}{2} \sum_{i=1}^2 \sum_{j=1}^2 \omega_{ij} \ln z_i \ln z_j + \frac{1}{2} \delta_2 Trend^2 \\
 & + \sum_{i=1}^3 \vartheta_i \ln y \ln w_i + \sum_{i=1}^2 \mu_i \ln y \ln z_i + \rho_i \ln y Trend + \sum_{i=1}^3 \sum_{j=1}^2 \sigma_{ij} \ln w_i \ln z_j \\
 & + \sum_{i=1}^3 \varphi_i \ln w_i Trend + \sum_{i=1}^2 \partial_i \ln z_i Trend + u + v
 \end{aligned} \tag{6}$$

The marginal cost is estimated as follows:

$$MC = \frac{TC}{y} \left[\alpha_1 + \alpha_2 \ln y + \sum_{i=1}^3 \vartheta_i \ln w_i + \sum_{i=1}^2 \mu_i \ln z_i + \rho_i Trend \right] \tag{7}$$

The Efficiency-adjusted Lerner index ($L_{e_adjusted}$) is calculated as follows:

$$L_{e_adjusted} = \frac{\left(\frac{\hat{TP}}{y} + \frac{\hat{TC}}{y} \right) - \hat{MC}}{\frac{\hat{TP}}{y} + \frac{\hat{TC}}{y}} \tag{8}$$

Bank Stability

The Z-score which was introduced by Roy (1952) reflects the probability of bank failure because it evaluates the overall stability at the bank level. The Z-score considers simultaneously the influences of the profitability, leverage and volatility of return on the stability or the failure probability of an individual bank. Consequently, both bank performance and bank risk are integrated into the Z-score. The Z-score measures the distance to default, which can be defined as the rate of the sum of return on average assets (or return on average equity) and equity ratio (EA) to the volatility of return on average assets (or return on average equity) So, the formula of the Z-score in terms of return on average assets (ROAA) or return on average equity (ROAE) respectively is:

$$Z - score_{ROAA} = \frac{ROAA + EA}{\sigma_{ROAA}} \tag{9}$$

$$Z - score_{ROAE} = \frac{ROAE + EA}{\sigma_{ROAE}} \tag{10}$$

Where:

ROAA is the ratio of profit before tax to average assets

ROAE is the ratio of profit before tax to average equity

EA is the ratio of the equity over total assets.

σ_{ROAA} and σ_{ROAE} mean the standard deviation of ROAA and ROAE, respectively.

The study measures the Z-score using a three-year rolling window to compute the mean value of ROAA (ROAE), EA at a specific year t. ROAA, ROAE, and EA at year t are calculated as the mean over 3 years including the present t year and the prior 2 years for an individual bank. σ_{ROAA} (σ_{ROAE}) is the standard deviation of ROAA (ROAE) over the time period. Higher Z-scores indicate more bank stability.

Data

Bank-specific data were retrieved from the Bank scope Fitch-IBCA database for Hong Kong banking over 2004– 2014. Data on listing status of banks are collected from the Hong Kong Stock Exchange (HKEX).

Country-specific data, such as growth of gross domestic product (GDP Growth) and inflation rate, were derived from the International Financial Statistics (IFS) data of the International Monetary Fund (IMF). After excluding banks that have missing data in more than two consecutive years and observations with negative values for other operating expense, the data consist of 245 observations from 23 commercial banks. An unbalanced panel dataset was used due to exclusion of inappropriate observations. The data were checked thoroughly and data problems such as missing values, inconsistencies and reporting errors were handled as appropriate.

Methodology

The study examines the relationship between bank competition, bank stability and bank efficiency using the baseline model:

Efficiency = $f(\text{bank competition, bank stability, bank-specific characteristics, macroeconomic environments})$

Here, the dependent variable (Efficiency) is cost efficiency of bank k at time t estimated by the SFA or DEA approaches. Bank competition is measured by the conventional Lerner (Lerner_con) or the efficiency-adjusted Lerner (Lerner_adj). Higher Lerner indices indicate less bank competition. Z-score proxies bank stability with higher scores show more bank stability. Stability_ROA and Stability_ROE are measured by $Z\text{-score}_{ROAA}$ and $Z\text{-score}_{ROAE}$ respectively. Bank-specific characteristics include bank size, revenue diversification, listing status, credit risk and liquidity risk. Bank size (SIZE) is measured by the natural logarithm of total assets of bank. This variable is expected to have a positive correlation with cost efficiency due to the exploiting benefits of economies of scale. In other words, large banks can capture the possible cost advantages associated with size. Revenue diversification (RD) is calculated as the ratio of non-interest income over total revenue. Listing status of banks (LIST) is a dummy variable which takes the 1 values if the bank is listed on the Hong Kong Stock Exchange (HKEx) and takes the 0 value if the bank is unlisted. Credit risk (measured as ratio of loans to assets) and liquidity risk (measured as ratio of deposits to assets). To account for the impacts of macro economic environments on cost efficiency of banks, three variables including inflation, gross domestic product growth (GDP Growth) and global financial crisis (CRISIS) are considered in our model. The CRISIS dummy which represents the global crisis is added in the model to assess the impact of the global crisis on the efficiency. CRISIS takes the value of one for the crisis year 2008 and 2009 and zero otherwise. According to Kumbhakar and Lovell (2000), when the value of a dependent variable lies between 0 and 1, this variable must be

transformed before estimation, or To bit regression must be used to estimate a limited dependent variable. Greene (2005) Supported the suggestion that a to bit model should be applied in the case of a dependent variable obtained from a first-stage regression. Consistent with banking literature on efficiency and competition (e.g.Coccoresse and Pellicchia (2010);Koetter et al. (2008);Turk Ariss (2010)), a To bit regression model, also called a censored regression model, is used here to examine the relationship between bank competition, bank stability and bank efficiency in Hong Kong.

First, the To bit regression is run to account for the censored nature of the dependent variable, X-efficiency. Due to the probability of “reverse causation” under the efficient structure paradigm, meaning that bank efficiency may affect market concentration and bank competition, the Wald test is employed to test for the exogeneity of bank competition.

The null hypothesis is that bank competition (measured by the Lerner index) are exogenous variables. Following Koetter et al. (2008, 2012) and Williams (2012), one-period lags of Lerner are used as instrumental variables for Lerner indices. If the Wald test statistic is significant, the null hypothesis of exogeneity is rejected, suggesting that bank competition (measured by the Lerner index) are treated as endogenous variables. In this case, To bit estimation can cause a bias. The instrumental variables technique (2SLS) is used here to address any endogeneity problems and avoid associated bias.

EMPIRICAL RESULTS

As shown in Table 2, average efficiency levels of banks in Hong Kong are quite high (approximate 93 percent for Efficiency_SFA and 79 percent for Efficiency_DEA). In line of the findings of Koetter et al. (2008)andTurk Ariss (2010), the efficiency-adjusted Lerner indices are, on average, higher than the conventional Lerner indices, suggesting that the later may overestimate market power levels. Therefore, using both Lerner specifications can provide robustness checks of estimates of competition.

Table2. Descriptive Statistics of Variables For Examining the Relationship between Bank Competition, Bank Stability and Bank Efficiency

	Mean	Std. Dev.	Min	Max
Efficiency_SFA	0.9339	0.0697	0.5597	0.9934
Efficiency_DEA	0.7871	0.1929	0.1366	1
Lerner_con	0.7400	0.2546	-0.5581	1.1006
Lerner_adj	0.8496	0.1427	0.4103	1.0956

Stability_ ROA	32.5551	12.7339	4.0930	63.6748
Stability_ ROE	7.0577	4.3705	1.3497	34
SIZE	16.2435	1.9707	11.7027	20.3063
Revenue diversification	0.2139	0.1131	-0.23	0.7224
LIST	0.2531	0.4357	0	1
Credit risk	0.4939	0.1328	0.0259	0.9239
Liquidity risk	0.8317	0.1251	0.0661	0.9365
Inflation (%)	2.7347	1.7669	-0.372	5.281
GDP Growth (%)	4.3253	3.1560	-2.459	8.7
CRISIS	0.1796	0.3846	0	1

Table 3 indicates the relationships between bank competition, bank stability and efficiency measured by the SFA approach using To bit regressions. As shown in the table 3, the relationships between Lerner indices (including both the conventional and the efficiency-adjusted Lerner) and bank efficiency are

positive, however, these findings are significant only for the conventional Lerner. Therefore, banks can exercise their market power to increase their efficiency. In other words, banks with higher competition levels may achieve lower efficiency scores.

Table3. The Relationships between Competition, Stability and Efficiency in the Hong Kong Banking: SFA Approach and to bit Regressions

Dependent variable: Efficiency_SFA								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Lerner_con	.0379 (*)	.0495 (**)	.0411 (*)					
Lerner_adj				.0010	.0088	.0046		
Stability_ROA	.0004			.0006			.0006	
Stability_ROE		-.0024 (*)			-.0017			-.0016
SIZE	.0076 (**)	.0091 (***)	.0077 (**)	.0075 (*)	.0088 (**)	.0078 (**)	.0074 (**)	.0085 (**)
Revenue diversification	.0133	-.0167	.0049	.0266	.0019	.0155	.0267	.0035
LIST	.0283 (**)	.0176	.0258 (*)	.0305 (**)	.0226	.0275 (**)	.0304 (**)	.0227
Credit risk	.0706 (*)	.0869 (**)	.0761 (*)	.0737 (*)	.0902 (**)	.0819 (**)	.0736 (*)	.0898 (**)
Liquidity risk	.0417	-.0232	.0322	.0540	.0030	.0404	.0541	.0042
Inflation	.0045 (*)	.0037	.0044 (*)	.0046 (*)	.0040	.0045 (*)	.0046 (*)	.0041
GDP Growth	.0049 (**)	.0054 (***)	.0049 (**)	.0042 (**)	.0044 (**)	.0042 (**)	.0042 (**)	.0044 (**)
CRISIS	.0386 (**)	.0410 (**)	.0381 (**)	.0334 (**)	.0333 (**)	.0321 (**)	.0334 (**)	.0329 (**)
Cons	.6493 (***)	.7007 (***)	.6658 (***)	.6619 (***)	.7058 (***)	.6835 (***)	.6631 (***)	.7165 (***)
Wald test								
Chi2	2.21	2.52	0.84	0.65	2.31	0.70		
Prob> chi2	0.1373	0.1122	0.3599	0.4203	0.1286	0.4032		
Number of obs	244	244	244	244	244	244	244	244
Log likelihood	330.41	331.52	330.05	328.92	328.91	328.21	328.92	328.88

Source: Author's calculation

Note: results from To bit regressions for the relationship between bank competition, bank stability and bank efficiency. Bank efficiency levels are calculated from a cost function by the SFA approach. The degree of competition is proxied by the Lerner index with higher values of Lerner indicating a lower degree of bank competition level. Both the conventional Lerner index (Lerner_con) and the efficiency-adjusted Lerner index (Lerner_adj) are reported. Stability_ROA and Stability ROE are calculated by Z-score_{ROAA} and Z-score_{ROAE}, respectively. Size is the natural logarithm of total assets account for bank size; Revenue diversification is calculated as the ratio of non-interest income over total revenue. LIST is a dummy variable

which takes the 1 values if the bank is listed on the Hong Kong Stock Exchange (HKEx) and takes the 0 value if the bank is unlisted. Credit risk is loan to asset ratio accounts; Liquidity risk is deposit to asset ratio; GDP growth is real gross domestic products growth; Inflation is inflation rate; CRISIS takes the value of one for the crisis year 2008 and 2009 and zero otherwise. The Wald test is used to test for the exogeneity of competition, under the null hypothesis that these are exogenous variables.

*, ** and*** denote statistical significance at the 10, 5 and 1%levels, respectively. The coefficients for bank stability have contrast signs. The coefficients for Stability_ROA are insignificantly positive. By contrast, the

coefficients for Stability_ ROE are negative but significant only for model 2. This shows that bank stability has a significant negative influence on bank efficiency when using the conventional Lerner indices as a proxy for bank competition and Stability_ ROE calculated by $Z\text{-score}_{ROAE}$. In contrast, both bank size and listing status are positively related to bank efficiency. The coefficients for bank size have positive signs for all models indicating that large banks are able to be more cost efficient than small ones. The positive associations between listing status and cost efficiency are significant only for the models using Stability_ ROA calculated by $Z\text{-score}_{ROAA}$. This result suggests that listed banks can attain higher levels of cost efficiency. Turning to bank risk variables, only credit risk has a significant relationship with cost efficiency. The coefficients for credit risk are positive for all models, thus there is a trade-off between credit risk and cost efficiency. Although banks incur higher credit risk, they are able to benefit from lending more, they can gain more profit and increase their size. Large banks can reduce cost to achieve a higher cost efficiency level. The liquidity risk and revenue diversification have insignificant impacts on bank cost efficiency for all models.

Macroeconomic environments have significantly effects on cost efficiency. The coefficients for GDP growth and crisis are significant and positive for all models. These findings indicate that banks can improve their cost efficiency when they operate under conditions of faster economic development (i.e higher GDP growth) and the 2008 – 2009 global financial crisis has a significant and positive effect on the cost efficiency of the Hong Kong banking. The reason may be that banks in Hong Kong decreased their deposit interest rates dramatically from 2.4 percent in 2007 to 0.4 percent in 2008 and even 0 percent over 2009 – 2014⁵, thus banks may spend less cost during the crisis and become more efficient. Moreover, the effect of inflation on cost efficiency is positive for all models but this finding is significant only when excluding Stability_ ROE from the models. Inflation of Hong Kong over 2004 – 2014 is not high (about 2.71% on average). Low inflation rates can hinder the economic development, thus decreasing banks' efficiency.

⁵Source: World Bank
(<http://data.worldbank.org/indicator>)

For robustness checks of the results, the study investigated the the relationship between bank competition, bank stability and bank cost efficiency estimated by DEA approach. According to figures reported in Table 4, the Wald tests show that exogeneity for bank competition is rejected at the 5% level for models 1, 2 and 3 but it is accepted for remaining models. Therefore, to bit estimation seems to be less appropriate than instrumental variable estimation (2SLS) for models 1 - 3. This result is consistent with the finding of Koetter et al. (2008) that the instrumental variables technique should be used. The relationship between bank competition, stability and cost efficiency in Hong Kong banking are analysed in detail below.

Note: results from to bit regressions for the relationship between bank competition, bank stability and bank efficiency. Bank efficiency levels are calculated from a cost function by the DEA approach. The degree of competition is proxied by the Lerner index with higher values of Lerner indicating a lower degree of bank competition level. Both the conventional Lerner index (Lerner_ con) and the efficiency-adjusted Lerner index (Lerner_ adj) are reported. Stability_ ROA and Stability_ ROE are calculated by $Z\text{-score}_{ROAA}$ and $Z\text{-score}_{ROAE}$, respectively.

Size is the natural logarithm of total assets account for bank size; Revenue diversification is calculated as the ratio of non-interest income over total revenue. LIST is a dummy variable which takes the 1 values if the bank is listed on the Hong Kong Stock Exchange (HKEx) and takes the 0 value if the bank is unlisted. Credit risk is loan to asset ratio accounts; Liquidity risk is deposit to asset ratio; GDP growth is real gross domestic products growth; Inflation is inflation rate; CRISIS takes the value of one for the crisis year 2008 and 2009 and zero otherwise. One-period lags of the Lerner index are used as instrumental variables for Lerner when 2SLS estimation is performed. The Wald test issued to test for the exo geneity of competition, under the null hypothesis that these are exogenous variables.

*, ** and*** denote statistical significance at the 10, 5 and 1% levels, respectively.

Table 4. The Relationships between Competition, Stability and Efficiency in the Hong Kong Banking: DEA Approach, to Bit And Two-Stage Least Square (2SLS) Regressions

Dependent variable: Efficiency_DEA											
	(1)		(2)		(3)		(4)	(5)	(6)	(7)	(8)
	Tobit	2SLS	Tobit	2SLS	Tobit	2SLS	Tobit	Tobit	Tobit	Tobit	Tobit
Lerner_con	.0598	.2074 (**)	.0402	.1867 (**)	.0625	.2244 (**)					
Lerner_adj							-.1058	-.0848	-.1065		
Stability_ROA	.0010	.0026 (*)					.0011			.0011	
Stability_ROE			.0114 (***)	.0124 (***)				.0115 (***)			.0117 (***)
SIZE	.0689 (***)	.0690 (***)	.0662 (***)	.0663 (***)	.0687 (***)	.0671 (***)	.0666 (***)	.0643 (***)	.0663 (***)	.0690 (***)	.0662 (***)
Revenue diversification	-.5139 (***)	-.5761 (***)	-.4537 (***)	-.5200 (***)	-.5195 (***)	-.5990 (***)	-.4779 (***)	-.4278 (***)	-.4825 (***)	-.4910 (***)	-.4375 (***)
LIST	-.0173	.0017	-.0015	.0132	-.0197	-.0084	-.0181	-.0027	-.0207	-.0160	-.0007
Credit risk	-.0771	-.1946	-.1028	-.2103 (*)	-.0660	-.1504	-.0318	-.0694	-.0180	-.0509	-.0850
Liquidity risk	-.4724 (***)	-.5100 (***)	-.2961 (*)	-.3705 (**)	-.5051 (***)	-.5963 (***)	-.4387 (***)	-.2754 (*)	-.4741 (***)	-.4412 (***)	-.2740 (*)
Inflation	.0009	-.0034	.0028	-.0012	.0009	-.0037	.0012	.0031	.0012	.0009	.0029
GDP Growth	.0158 (***)	.0183 (***)	.0143 (***)	.0165 (***)	.0158 (***)	.0185 (***)	.0140 (***)	.0130 (***)	.0139 (***)	.0148 (***)	.0136 (***)
CRISIS	.0578 (*)	.0768 (**)	.0503	.0655 (**)	.0561 (*)	.0738 (**)	.0468	.0423	.0444	.0498	.0448
Cons	.0689	-.0071	-.0689	-.0727	.1267	.1524	.1894	.0318	.2557	.0710	-.0678
Wald test											
Chi2	3.77		3.85		4.27		0.55	0.27	0.35		
Prob> chi2	0.05		0.05		0.04		0.46	0.60	0.55		
Number of obs	244		244		244		244	244	244	244	244
Log likelihood	97.87		102.24		97.67		97.89	102.33	97.66	97.48	102.05

Source: Author's calculation

According to the results from 2SLS regressions, the coefficients for Lerner_con are positive and significant suggesting that bank competition is negatively related to cost efficiency.

These findings provide strong supports to the above analysed results when considering bank efficiency measured by SFA approach. Similar to the results from table 3, the coefficients for Lerner_adj are insignificant. The impact of bank stability on bank efficiency is positive. This findings are significant for only model 1 considering the variable Stability_ROA and for all models including the variable Stability_ROE.

The significant positive relationship between Stability_ROA and Efficiency_DEA provides more support to the case using Efficiency_SFA that banks with higher stability levels may attain greater cost efficiency scores. Nevertheless, the signs of the coefficients for Stability_ROE are contrast when bank efficiency measured by different approaches.

Like the results when using Efficiency_SFA, bank size has a significant and positive relationship with bank efficiency for all models. By contrast, the all coefficients for RD are

significant negative providing more support to a negative impact of revenue diversification on cost efficiency.

The coefficients for credit risk is negative but this finding is significant only for model 2 using the conventional Lerner (Lerner_con) and stability measured by Z-score_{ROAE} (i.e.Stability_ROE) by the 2SLS regression. Therefore, these results are not in line with those obtained when using efficiency measured by SFA approach as a dependent variable. Liquidity risk is negative related to bank efficiency and this finding is significant for all models, thus lending more support to the case using Efficiency_SFA that banks with higher liquidity risk are able to be less efficient.

By contrast, all coefficients for both GDP growth and crisis are positive. The impact of GDP growth on bank efficiency is positive and significant for all models. The relationship between crisis and bank efficiency is significant when using the conventional Lerner and 2SLS regression. As a result, the effects of GDP growth and crisis on bank efficiency measured by SFA and DEA approaches are positive. The impact of listing status and inflation on bank efficiency are insignificant for all models.

CONCLUSIONS

This paper analysed the relationships between bank competition, bank stability, and bank efficiency in Hong Kong using data for 23 commercial banks over the period 2004 – 2014. For robustness checks of the results, bank efficiency is measured by both the parametric approach (SFA) and the non-parametric approach (DEA window analysis). The study estimated competition and stability at the bank level. Both the conventional Lerner and the efficiency-adjusted Lerner are used as proxies for bank competition. Higher indices indicate lower bank competition levels. Moreover, Z-score is used as a direct measures of bank stability. Higher Z-scores indicate more bank stability.

The findings suggest that bank competition is negatively related to cost efficiency. This finding is significant only when using the conventional Lerner indices. Banks with higher stability levels (measured by $Z\text{-score}_{ROAA}$) may attain greater cost efficiency scores. However, the impacts of bank stability (measured by $Z\text{-score}_{ROAE}$) on bank efficiency are significantly negative when efficiency is measure by the SFA approach but they turns significantly positive for the DEA approach

Bank size has a highly significant positive effect on cost efficiency, suggesting that larger banks are able to attain higher levels of cost efficiency. Listing status also has positive impact on cost efficiency. Listed banks have higher cost efficiency scores than non-listed banks, thus banks are encouraged to be listed on Hong Kong Stock Exchange (HKEx) to improve their efficiency. By contrast, revenue diversification is negatively related to cost efficiency, thus banks with higher non-interest revenue to total revenue ratios become more efficient. Turning to impacts of bank risk on bank efficiency, the signs of relationship between credit risk and bank efficiency are mixed when considering bank efficiency measured by different approaches. They are positive for efficiency (SFA) but turn negative for efficiency (DEA). By contrast, liquidity risk has a negative relationship with cost efficiency, thus banks with higher liquidity risk are able to be less efficient.

Macroeconomic environments also influence significantly cost efficiency of banks in Hong Kong over the studied period. Banks become more efficient in higher inflation conditions and they seem to control cost efficiently and achieve

higher cost efficiency levels when GDP growth rates increase. Additionally, banks in Hong Kong decreased their deposit interest rates dramatically over 2007 – 2014, therefore, banks may spend less cost during the crisis and become more efficient.

REFERENCES

- [1] AIGNER, D., LOVELL, C. A. K. & SCHMIDT, P. 1977. Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, 6 21-37.
- [2] ALTUNBAS, Y., CARBO, S., GARDENER, E. P. M. & MOLYNEUX, P. 2007. Examining the relationships between capital, risk and efficiency in European banking. *European Financial Management*, 13, 49-70.
- [3] ANGELINI, P. & CETORELLI, N. 2003. The effects of regulatory reform on competition in the banking industry. *Journal of Money, Credit & Banking (Ohio State University Press)*, 35, 663-684.
- [4] BANKER, R. D., CHARNES, A. & COOPER, W. W. 1984. Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis. *Management Science*, 30, 1078-1092.
- [5] BATTESE, G. E. & COELLI, T. J. 1995. A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data. *Empirical Economics*, 20, 325-332.
- [6] BERGER, A. N. & DEYOUNG, R. 1997. Problem loans and cost efficiency in commercial banks. *Journal of Banking & Finance*, 21, 849-870.
- [7] BERGER, A. N. & HANNAN, T. H. 1998. The Efficiency Cost of Market Power in the Banking Industry: A Test of the "Quiet life" and Related Hypotheses. *The Review of Economics and Statistics*, 80, 454-465.
- [8] BERGER, A. N., HASAN, I. & ZHOUD, M. 2009. Bank ownership and efficiency in China: What will happen in the world's largest nation? *Journal of Banking and Finance*, 33, 113-130.
- [9] BERGER, A. N. & MESTER, L. J. 1997. Inside the black box: What explains differences in the efficiencies of financial institutions? *Journal of Banking and Finance*, 21, 895-947.
- [10] CASU, B. & GIRARDONE, C. 2006. Bank competition, concentration and efficiency in the single European market. *Manchester School*, 74, 441-468.
- [11] AIGNER, D., LOVELL, C. A. K. & SCHMIDT, P. 1977. Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, 6 21-37.
- [12] ALTUNBAS, Y., CARBO, S., GARDENER, E. P. M. & MOLYNEUX, P. 2007. Examining

- the relationships between capital, risk and efficiency in European banking. *European Financial Management*, 13, 49-70.
- [13] ANGELINI, P. & CETORELLI, N. 2003. The effects of regulatory reform on competition in the banking industry. *Journal of Money, Credit & Banking* (Ohio State University Press), 35, 663-684.
- [14] BANKER, R. D., CHARNES, A. & COOPER, W. W. 1984. Some models for estimating technical and scale inefficiencies in Data Envelopment Analysis. *Management Science*, 30, 1078-1092.
- [15] BATTESE, G. E. & COELLI, T. J. 1995. A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data. *Empirical Economics*, 20, 325-332.
- [16] BERGER, A. N. & DEYOUNG, R. 1997. Problem loans and cost efficiency in commercial banks. *Journal of Banking & Finance*, 21, 849-870.
- [17] BERGER, A. N. & HANNAN, T. H. 1998. The Efficiency Cost of Market Power in the Banking Industry: A Test of the "Quiet life" and Related Hypotheses. *The Review of Economics and Statistics*, 80, 454-465.
- [18] BERGER, A. N., HASAN, I. & ZHOUD, M. 2009. Bank ownership and efficiency in China: What will happen in the world's largest nation? *Journal of Banking and Finance*, 33, 113-130.
- [19] BERGER, A. N. & MESTER, L. J. 1997. Inside the black box: What explains differences in the efficiencies of financial institutions? *Journal of Banking and Finance*, 21, 895-947.
- [20] CASU, B. & GIRARDONE, C. 2006. Bank competition, concentration and efficiency in the single European market. *Manchester School*, 74, 441-468.
- [21] CASU, B. & GIRARDONE, C. 2009. Does competition lead to efficiency? The case of EU commercial banks. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1200362.
- [22] CHARNES, A., COOPER, W. W. & RHODES, E. 1978. Measuring the efficiency of decision making unit. *European Journal of Operational Research*, 2, 429-444.
- [23] CHEN, C. 2009. Bank efficiency in Sub-Saharan African Middle-Income Countries. IMF Working Paper, WP/09/14, International Monetary Fund.
- [24] COCCORESE, P. & PELLECCIA, A. 2010. Testing the 'quiet life' hypothesis in the Italian banking industry. *Economic Notes*, 39, 173-202.
- [25] COELLI, T. J., RAO, D. S. P., O'CONNELL, C. J. & BATTESE, G. E. 2005. An introduction to efficiency and productivity analysis, New York, Springer.
- [26] DE GUEVARA, J. F., MAUDOS, J. & PÉREZ, F. 2005. Market power in European banking sectors. *Journal of Financial Services Research*, 27, 109-137.
- [27] DELIS, M. D. & TSIONAS, E. G. 2009. The joint estimation of bank-level market power and efficiency. *Journal of Banking & Finance*, 33, 1842-1850.
- [28] DRAKE, L., HALL, M. J. B. & SIMPER, R. 2006. The impact of macroeconomic and regulatory factors on bank efficiency: A non-parametric analysis of Hong Kong's banking system. *Journal of Banking and Finance*, 30, 1443-1466.
- [29] FANG, Y., HASAN, I. & MARTON, K. 2011. Bank efficiency in South-Eastern Europe. *Economics of Transition*, 19, 495-520.
- [30] FARE, R., GROSSKOPF, S. & LOVELL, K. C. A. 1985. The measurement of efficiency of production, Kluwer-Nijhoff Publishing.
- [31] FIORDELISI, F., MARQUES-IBANEZ, D. & MOLYNEUX, P. 2011. Efficiency and risk in European banking. *Journal of Banking and Finance*, 35, 1315-1326.
- [32] GREENE, W. 2005. Reconsidering heterogeneity in panel data estimators of the stochastic frontier model. *Journal of Econometrics*, 126, 269-303.
- [33] HICKS, J. R. 1935. Annual Survey of Economic Theory: The Theory of Monopoly. *Econometrica*, 3, 1-20.
- [34] HUGHES, J. P. & MESTER, L. J. 1998. Bank capitalization and cost: Evidence of scale economies in risk management and signaling. *Review of Economics & Statistics*, 80, 314-325.
- [35] HUGHES, J. P. & MOON, C. 1995. Measuring bank efficiency when managers trade return for reduced risk. Department of Economics Rutgers University Working Paper, 20, 1995. .
- [36] KASMAN, A. & CARVALLO, O. 2014. FINANCIAL STABILITY, COMPETITION AND EFFICIENCY IN LATIN AMERICAN AND CARIBBEAN BANKING. *Journal of Applied Economics*, 17, 301-324.
- [37] KOETTER, M., KOLARI, J. W. & SPIERDIJK, L. 2008. Efficient Competition? Testing the 'quiet life' of U.S. banks with adjusted Lerner indices. Working Paper, Groningen University.
- [38] KOETTER, M., KOLARI, J. W. & SPIERDIJK, L. 2012. Enjoying the quiet life under deregulation? Evidence from adjusted Lerner indices for U.S. banks. *Review of Economics & Statistics*, 94, 462-480.
- [39] KUMBHAKAR, S. C. & LOVELL, C. A. K. 2000. *Stochastic Frontier Analysis*, Cambridge MA: Cambridge University Press.

- [40] KWAN, S. & EISENBEIS, R. A. 1997. Bank risk, capitalization, and operating efficiency. *Journal of Financial Services Research*, 12, 117.
- [41] KWAN, S. H. 2006. The X-efficiency of commercial banks in Hong Kong. *Journal of Banking and Finance*, 30, 1127-1147.
- [42] LIN, S. L., PENM, J. H. W., GONG, S. C. & CHANG, C. S. 2005. Risk-based capital adequacy in assessing on insolvency-risk and financial performances in Taiwan's banking industry. *Research in International Business and Finance*, 19, 111-153.
- [43] MARQUEZ, R. 2002. Competition, Adverse Selection, and Information Dispersion in the Banking Industry. *The Review of Financial Studies*, 15, 901-926.
- [44] MAUDOS, J. & DE GUEVARA, J. F. 2007. The cost of market power in banking: Social welfare loss vs. cost inefficiency. *Journal of Banking & Finance*, 31, 2103-2125.
- [45] MEEUSEN, W. & VAN DEN BROECK, J. 1977. Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review*, 18, 435.
- [46] PRUTEANU-PODPIERA, A., WEILL, L. & SCHOBERT, F. 2008. Banking competition and efficiency: A micro-data analysis on the Czech banking industry. *Comparative Economic Studies*, 50, 253-273
- [47] ROY, A. D. 1952. Safety First and the Holding of Assets. *Econometrica*, 431.
- [48] SCHAECK, K. & ČIHÁK, M. 2008. How does competition affect efficiency and soundness in banking? New empirical evidence. Working Paper Series.
- [49] SEALEY, C. W., JR. & LINDLEY, J. T. 1977. Inputs, Outputs, and a Theory of Production and Cost at Depository Financial Institutions. *The Journal of Finance*, 32, 1251-1266.
- [50] TAN, Y. & FLOROS, C. 2013. Risk, capital and efficiency in Chinese banking. *Journal of International Financial Markets, Institutions & Money*, 26, 378-393.
- [51] TURK ARISS, R. 2010. On the implications of market power in banking: Evidence from developing countries. *Journal of Banking and Finance*, 34, 765-775.
- [52] WEILL, L. 2013. Bank competition in the EU: How has it evolved? *Journal of International Financial Markets, Institutions & Money*, 26, 100-112.
- [53] WILLIAMS, J. 2004. Determining management behaviour in European banking. *Journal of Banking and Finance*, 28, 2427-2460.
- [54] WILLIAMS, J. 2012. Efficiency and market power in Latin American banking. *Journal of Financial Stability*, 8, 263-276.
- [55] ZHANG, X. & DALY, K. 2012. Performance of China-owned banks in Hong Kong. *International Journal of banking and finance*, 9, 72-87.
- [56] ZHANG, J., JIANG, C., QU, B. & WANG, P. 2013. Market concentration, risk-taking, and bank performance: Evidence from emerging economies. *International Review of Financial Analysis*, 30, 149-157.

Citation: Hien Thu Phan, Hanh Thi My Phan, Kevin Daly, "Study of Hong Kong Banking System", *Journal of Banking and Finance Management*, 2(2), 2019, pp. 24-38.

Copyright: © 2019 Kevin Daly. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.