MODELING THE INTER-TEMPORAL RELATIONSHIP AMONG RISK, CAPITAL & EFFICIENCY IN ASEAN COMMERCIAL BANKS

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Abstract

This paper analyses the inter-temporal relationship between bank risk, capital and efficiency for the sample of commercial banks from five countries in ASEAN community between 2005 and 2015. The relationship is identified using Granger causality techniques to test the hypotheses of management behavior in ASEAN commercial banking developed by Berger and DeYoung. The results indicate that efficiency does not play a significant role in the behavior of banks in ASEAN in adjusting their capital and risk level. More efficient banks appear to be more capitalised. There is inverse relationship between capital and risk suggesting that moral hazard incentives might fall as the level of capital increases.

1. Introduction

Banking system has been increasingly integrated as a result of globalization and trade integration. ASEAN region is also a part of the system and highly relevant in the region and global context. As part of the integration process, the behavior of banks in the period of improved international and local regulations receives tremendous emphasis. Banks in developed countries are forced to operate in higher competitive environment meanwhile maintain safe capital position and limit excessive risk taking by regulators. The situation is not different in developing and emerging countries given the globalization but in different regulatory and economic context.

A number of studies have been carried out to investigate the relationship among bank capital, risk and efficiency. (Altunbas, Carbo, Gardener, & Molyneux, 2007; A. N. Berger & DeYoung, 1997a; Fiordelisi, Marques-Ibanez, & Molyneux, 2011; Kwan & Eisenbeis, 1997; Williams, 2004a). However, there are only limited studies focusing on the inter-temporal and causal relationship between bank risk, capital and efficiency. Particularly, research on this particular relationship is not performed in the ASEAN region. The ASEAN is currently emerged as an important player as a community in Asia and in the world with strong commitment toward a globally competitive single market. As a result, the integration of financial sector is indispensable to contribute to a resilient banking system which will foster the growth in the region. Therefore, it is important that the behavior of banks in the region can be studied and understood to provide implications for individual banks as well as bank regulators.

The paper follows the approach of understanding types of bank management behavior namely bad management, bad luck, skimping and moral hazard as initially proposed by Berger & De Young (1997). Granger causality method showing the intertemporal order of risk, capital and efficiency is adopted. Commercial banks in the US exhibit all the above four types of management behavior (A. N. Berger & DeYoung, 1997a), whereas European banks indicate evidence of bad management and moral hazard behavior (Fiordelisi et al., 2011; Williams, 2004a).

Our aim is to investigate whether banks in ASEAN region provide any evidence of management behavior. Specifically, through the causality test, we assess whether bank efficiency exerts any impact on bank risk and capital ad indicated in literature by Hughes, Mester & Moon (1995). We want to shed light on the issue that bank managers in this region can behave differently given the diversity in macroeconomic environment and the stages of bank development. Our study focuses on 5 emerging economies of ASEAN including Thailand, Malaysia, Philippines, Indonesia and Vietnam. Data set covers a period of ten years from 2005 to 2015. Our variables of interest including different measures of bank risk and efficiency.

The rest of the paper is organized as follows: section 2 covers a literature review, section 3 presents the hypotheses and research methodology. Analysis of result is explained in section 4. Section 5 presents the robustness checks and section 6 concludes the paper.

2. Literature review

Banking sector plays a crucial role in the development of any economic system. Yet due to the complex function of financial institutions, the sector is highly regulated. Banks invest in risky and illiquid assets in the form of loans using safe and liquid funds from creditors (Hughes & Mester, 1998). Credit risk from loans and liquidity risk from the mismatch between loans and deposits shape banking activities and the level of equity capital in the event of financial distress. The threat of bank insolvency determines the regulatory intervention. Bank capital helps lower probability of insolvency and provide incentives for managing risk to protect stakeholders. The higher the level capitalization, the safer the position of depositors and creditors. Understanding the behavior of banks under regulation becomes an interesting research topic among bank regulators and the academia. Yet researchers have not agreed on the behavior of banks across countries. Evidence from previous researches remain diverse and inconclusive on the determinants of bank risk taking behavior.

Bank's choice of capital and risk can be explained by a number of theories including agency theory, moral hazard, ownership structure and managerial incentives. Numerous research works have been carried out to understand the behavior of banks in order to test the impact of bank regulation on such behavior. Many theories on the relation of bank capital and risk have been developed and empirically tested in various countries. Among those we can identify two major streams which work on the relationship among bank capital, risk and efficiency.
One focus on the relationship of capital and risk taking, identifying the impact of capital regulation on bank capital and risk. This strand of research includes the classic work of Shrieves and Dalh (1992) and a series of empirical evidence from many different countries in different periods. Among those studies, we can mention the work of Jacques & Nigro (1997), Aggarwal & Jacques (1998), Ediz et al (1998), Rime (2001), Hoid (2004) in developed countries of US, UK, Switzeland, Germany. Several other researches have been done in developing countries or identify the effect of capital requirement across different countries including Hassan & Hussain (2005), Van Roy (2008), Floquet (2008), Camara et al (2013). Researchers have agreed on the simultaneous change in bank capital and risk taking with the impact of exogenous factors. Such behaviour is constrained by regulatory pressure, resulting trade-off between capital and risk. Therefore, bank capital requirement such as Basel standard can effectively act as pressure to limit bank risk taking.

The other stream of research argues the role of efficiency in bank risk taking behavior. Hughes & Moon (1995) and Hughes and Mester (1998) identify the impact of efficiency on bank capital and risk. A positive relationship between risk and capital was observed but a negative relationship between inefficiency and bank risk was uncovered. They argued that bank managers are risk averse and they use the level of capital to control risk, using more inputs to reduce risk and preserve capital. The early works of Hughes, Mester and Moon start a strand of literature on the intertemporal relationship among bank efficiency, risk and capital. Among researches on bank efficiency, risk and capital, there appears to be two main dimensions. One dimension works on the association of bank risk and efficiency using Granger causality test with classic work of Berger and De Young (1997) and the other dimension looks at the tradeoffs between bank risk and efficiency. Both dimensions provide evidence on the effect of efficiency on bank capital and risk.

Berger & De Young (1997) review and use Granger-causality analysis to test the inter-relationship between problem loans, cost efficiency and bank capital and propose four different hypotheses. Under bad luck hypothesis, external shock might cause non-performing loans to increase. Thereby banks react by incurring additional costs to monitor and work out with delinquent loans resulting in decrease in cost efficiency. Bad management hypothesis assumes that low cost efficiency is the result of poor management practices. Inadequate credit scoring, loan monitoring and controlling are caused by bad managers, leading to mounting problem loans. Both bad luck and bad management hypotheses predict negative association of non-performing loans and cost efficiency. Skimping hypothesis refers to the tradeoff between short term operating costs for long term loan performance. A bank may increase cost efficiency through declining cost of credit appraisal, monitoring and controlling loans but at the expense of long term problem loan portfolio. Skimping hypothesis predict positive relationship between efficiency and problem loans. Moral hazard hypothesis does not imply the direct association of problem loans and efficiency. Bank managers, particularly weakly capitalised banks, can take excessive risk given risk can be borne by creditors, thereby increasing the level of bad loans. Moral hazard provides implications for regulatory policies on non-performing loan problems, capital and risk requirement. Moral hazard can have impact on the above three hypotheses.

Berger & De Young (1997) analyses US commercial bank data for the period from 1985 to 1994. The results of their work support bad luck and bad management hypotheses. The interrelationship between efficiency and loan quality are two ways. Increase in nonperforming loans followed by the decrease in cost efficiency and vice versa. Evidence for skimping hypothesis is observed for only a subset of banks which are efficient over time. The findings from their analysis also reveal that banks with low capital ratios increase nonperforming loans as a response to moral hazard incentive. William (2004) extended the test of Berger & De Young (1997) for European saving banks. This author found strong statistical evidence from European banks to support the bad management hypothesis which implies that quality of loans is poor for banks with low efficiency. Skimping hypothesis was rejected for cost efficient banks. Bad luck hypothesis and moral hazard behaviour were not clearly evidenced as compared to US result of Berger & De Young. William's finding implies prudent behaviour among managers of European saving banks. Bank managers of those banks tend to increase capital in response to reduction in efficiency. This result of study is inconsistent with that Berger & De Young in the US. Banking sector is becoming more competitive due to deregulation process, rapid change in technology and stronger financial integration. Such competition may lead to excessive risk taking by banks and hence creates pressures on level of capital. To boost bank performance in a competitive environment, efficiency plays a vital role. According to Fiodelisi (2011), banks are forced to operate closer to the efficient frontier. Hence the inter-temporal relationship among bank risk, capital and efficiency has received tremendous emphasis. Fiodelisi, Marques Ibanez, Molyneux (2011) continue the study on bank risk, capital and efficiency for European countries with a large data set of commercial banks using various measures of banking risk, capital and efficiency. Evidence to support bad management hypothesis is indicated in the study as low bank efficiency Granger causes higher risk. They find positive relationship between cost efficiency and bank capital which is consistent with Berger & DeYoung (1997) and William (2004). It implies that more efficient banks seem to be better capitalised and higher bank capital tends to have positive impact on level of efficiency. In contrast to Berger & De Young (1997), the research found little evidence on the causal link of bank risk and capital. The result of Fiodelisi et al (2011) suggests more attention on efficiency from the point of view of regulators to ensure the objective of financial stability in the banking system. Conflicting result in US and EU requires further investigation into the relationship of bank capital, risk and efficiency. In another dimension, Kwan and Eisenbeis (1997) investigate how efficiency and bank risk affect capital decisions of bank managers.

Kwan & Eisenbeis (1997) focus on the association among risk, bank capital and efficiency of banks using two underlying theories: agency problems and asymmetric information.
Jensen (1986) and Stultz (1990) indicate the two theories – agency costs and information

asymmetries- that explain the behavior of banks. Some banks respond to increased cost of capital by taking on more risk and some other may reduce risk. According to Jensen (1986), under agency theory, managers tend to maximize their wealth at the expense of shareholders. They are incented to maximize firm growth beyond efficient size, which decrease efficiency, lower returns and hence conflict with shareholders' interests. Managers tend to avoid market monitoring by relying on internal funding, over-invest and/or engaging inefficient behavior. Jensen (1986) also points out that debts can induce managers to behave efficiently. Under asymmetric information theory, shareholders are not well informed of quality of investment as management. Such information asymmetry leads to inefficient investment particularly when cash flow is low (Stulz, 1990).

A different hypothesis proposed by Hughes, Lang, Mester and Moon (1995) indicate opposite sign in the relationship between risk and inefficiency. They argued that as managers are risk averse, they are willing to trade off reduced earnings for less risk. They will incur additional cost of granting and monitoring loans thereby accepting lower efficiency in for higher loan quality. Such argument implies positive relationship between loan quality and inefficiencies.

Kwan & Eisenbeis (1997) test the simultaneous relationship among bank leverage, risk and inefficiencies for 254 banks in the US over the period from 1986 to 1991. They found the asymmetry in the relationship of risk and inefficiencies in the two different equations. Evidence from the capital equation is consistent with moral hazard and risk taking hypotheses that less efficient banks tend to assume more risk and also weakly capitalised. Result from inefficiency equation the hypothesis on the positive relationship between asset quality and inefficiencies of Hughes, Lang, Mester and Moon (1995).

Following the empirical work for US banks, Altunbas et al (2007) tested the intertemporal relationship among risk, capital and efficiency in European banks. Interestingly, the relationship as predicted by agency theory and found by Kwan & Eisenbeis (1997) did not hold for European sample. Inefficient banks in Europe appear to maintain higher capital and take on less risk. There exists inverse relationship between capital and risk for more efficient banks. Regulation might be the factor that allow more cost efficient banks to be more flexible in tradeoff capital for risk as compared to less efficient ones. The interconnection among risk, capital and inefficiency is not statistically evidenced for European banks.

Inconsistent results from US and European leave inconclusive answer on which theory support the intertemporal relationship among risk, capital and inefficiencies. More empirically studies have been performed in various countries.

Deelchand and Paggett (2009) analysed the relationship of bank risk taking with capital and efficiency for Japanese cooperative banks for the period 2003 to 2006. The empirical results indicate that inefficient Japanese cooperative banks take on more risk and hold more capital. The result support moral hazard theory. Bank capital has negative impact on efficiency which is contradictory to the result of study in the US by Kwan & Eisenbeis (1997) and European saving banks by Altunbas et al (2007). The difference in result might be attributable to the characteristics of co-opearative banks in Japan which are less risk taking as compared to commercial banks.

Several other studies have investigated the nexus among capital, risk and efficiency with data from different countries in other regions. Results seem vary with countries and time period. Das & Ghosh (2004), Nguyen & Nghiem (2015) look at Indian banks in different period but find consistent result in negative relationship between risk and efficiency and better capitalised banks take on less risk. They find contradicting results in the association of capital and efficiency. Lemonakis et al (2015), Bitar et al (2018), Louati et al (2016) also observe negative associate of bank risk and efficiency. Other studies find positive relationship between risk and efficiency, suggesting more efficient banks assume more risk including Tan & Floros (2013) with Chinese banks, Tahir & Mongid (2012, 2013) with banks in ASEAN region, Manta & Badircea (2015) with Romanian sample. Most empirical studies find evidence of negative asociation between capital and risk which support moral hazard hypothesis with the exception of Banta & Badircea (2015) and Louati et at (2016). The relation of bank capital and efficiency remains unclear as some works suggest that better capitalised banks are more efficient (Tahir & Mongid, 2013, Bitar et al, 2018) where others find the reverse (Bashir & Hassan, 2017, Louati et al, 2016).

Table 1: Summary of empirical studies on risk, capital and efficiency presents a summary of empirical studies on the interconnection among risk, capital and efficiency. It indicates diverse results for different samples and different periods of study and even vary within the same study but for different sub-samples. Such findings also reflect on the inconclusive answer from theoretical studies.

3. Hypotheses and research methodology

3.1. Hypotheses

As banking system is becoming more competitive and stronger integrated into the globalization, the resilience of banking sector is of heightened concern. Banking regulations are developed and implemented worldwide in order to promote the stability of international financial system. The purpose of banking regulations such as Basel Accord is to limit excessive risk taking of banks, forcing banks to maintain level of capital to absorb risks. However, banks are also under pressure from external stakeholders to perform well to generate returns to capital holders. The three aspects of risk, capital and performance are of importance for banks. Therefore, understanding bank behavior is important for both regulators and bank managers.

The process of bank integration and regulation has created stronger pressure on bank's level of capital and risk monitoring. Competition forces banks to improve efficiency. Therefore, the trade off of bank capital, risk and efficiency need more attention. The aim of the paper is to assess the inter-temporal relationship between risk, capital and efficiency. Specifically, the focus is on the impact of efficiency on risk and capital. In turn changes in bank risk and capital might have influence on level of efficiency.

The question can be elaborated into the following hypotheses.

H1: There is negative relationship between bank risk and efficiency. Such negative relationship support either the theory of bad management or bad luck depending on the order of causality.

Exogenous shock (bad luck) can lead to problem loans and consequently increase risk. Banks will incur additional costs to deal with higher risk, thereby lower efficiency. On the contrary, poor management of loans which have lower costs and higher cost efficiency results in higher risk of non-performing loans. This implies negative association in a reverse order of consequence with bad luck hypothesis (Berger & De Young, 1997).

Positive relationship shows indication of cost skimping theory which pointing out the trade-off between low cost of controlling loans to achieve higher short term efficiency for increasing risk of future problem loans (Berger & De Young, 1997).

H2: There is positive relationship between bank capital and efficiency, meaning that better capitalised banks are more efficient. This relationship does not link to any specific hypothesis, but banking literature has identified that risk and inefficiency are associated with losses of capital (Berger & De Young, 1997).

H3: There is negative causal relationship between bank capital and risk. The negative correlation supports moral hazard theory implying more risk taking behavior of banks when the level of capital is low (Jeitschko and Jeung, 2005) and Fiodelisi (2011).

3.2. Econometric models

Granger causality test is used to investigate the inter-temporal relationship among bank risk, capital and efficiency (A. N. Berger & DeYoung, 1997a; Fiordelisi et al., 2011; Williams, 2004b). Explanation for Granger causality is that y_t is causing x_t. Granger test suggests regressing x_t on its own lags and a set of lagged y_t. If lagged y_t provides a statistically significant explanation of x_t, y_t Granger causes x_t. Granger causality tests does not prove the economic causation between the two variables, but it indicates statistical association. Granger causality have been widely used in banking literature. (A. N. Berger & DeYoung, 1997a; Casu & Girardone, 2009; Fiordelisi et al., 2011; Luo, Tanna, & De Vita, 2016; Williams, 2004b). As we test the four hypotheses developed by A. N. Berger & DeYoung (1997b) of bad luck, bad management, cost skimping and moral hazard which imply the time-order and sign of the relationship, Granger causality test is relevant.

To identify the inter-temporal relationship between risk, capital and efficiency, the three equations are estimated:

$risk_{i,t} = f_1(risk_{i,lag}, xeff_{i,lag}, cap_{i,lag}, Z_{i,t}) + \varepsilon_{i,t}$ (1)

$xeff_{i,t} = f_2(risk_{i,lag}, xeff_{i,lag}, cap_{i,lag}, Z_{i,t}) + \nu_{i,t}$ (2)

$cap_{i,t} = f_3(risk_{i,lag}, xeff_{i,lag}, cap_{i,lag}, Z_{i,t}) + \omega_{i,t}$ (3)

Z are control variables including factors affecting the efficiency-risk-capital relationship. The above three equations imply time ordered and signed relationship among the three variables (risk, cost efficiency and capital).

Equation (1) tests whether changes in cost efficiency and capital Granger cause the change in bank risk. This equation is used to test bad management hypothesis. A priori bad management indicates negative signed of the sum of coefficients on lagged cost efficiency in risk equation. A positive sign will suggest cost skimping hypothesis. Equation (1) also tests moral hazard behaviour which predicts the negative sign of the sum of the coefficients on lagged capital on the risk.

Equation (2) evaluates the causality relationship of risk and capital on cost efficiency. Equation (2) assesses whether changes in bank risk and capital temporally precede change in cost efficiency. Equation (2) tests bad luck hypothesis if the sign of the sum of coefficients on lagged risk is negative.

Equation (3) does not test any specific hypothesis among the four, but to test changes in cost efficiency and risk affect bank capital.

3.3. Variables

Table 2 presents the summary of variables used in the model. To measure the bank risk, we use the ratio of loan loss provision to loan as proxy. This measure is commonly used in literature to account for bank risk (Tan & Floros, 2013; Williams, 2004). This measure focuses on credit risk and backward looking as it is based on accounting data. The ratio of Equity to total assets is used as measure of bank capital. This proxy is widely used in literature for bank capital and it captures the banks' financial cushion to absorb loan losses. (A. N. Berger & DeYoung, 1997a; Fiordelisi et al., 2011; Williams, 2004b).Cost efficiency of banks is estimated using stochastic frontier analysis with detail discussed in a separate section.

We also include a set of control variables which account for the size of banks (logarithm of total assets), bank business structure which identifies bank income diversification proxied by HHI (Herfindahl Hirschman Index). (Laeven, 2007, Chronopoulos, 2011; Elyasiani & Wang,2012). The higher the HHI, the higher the degree of income diversification.

$$\text{HHI} = 1 - [\left(\frac{non\ interest\ income}{total\ income}\right)^2 + \left(\frac{net\ interest\ income}{total\ income}\right)^2]$$

We also account for banking sector difference by using concentration ratio CON (ratio of 5 largest banks over the whole bank sector) and account for macroeconomic factor using domestic credit provided by banks in the economy CRE. To control the differences among countries, we use the two macroeconomic factors of GDP growth rate, inflation rate and corruption index as country-specific control variables.

3.4. Cost efficiency

To measure bank efficiency, we estimate cost efficiency using the stochastic frontier approach. Cost efficiency is the most commonly used in literature. (Altunbas et al., 2007; Altunbaş & Chakravarty, 2001; Fiordelisi et al., 2011; Fries & Taci, 2005; Kwan & Eisenbeis, 1997; Willesson, 2015; Williams, 2004b). Cost efficiency measures the distance of a bank's cost in relation to the cost of the best practice bank. In other words, banks are considered inefficient if costs are higher than the most efficient bank producing the same output under the same conditions.

Efficiency scores are estimated using the stochastic frontier analysis initially proposed by Aigner et al (1977), Meeusen and Van den Broeck (1977) and Battese & Corra (1977). These models indicate the two components of error term. The first component is symmetric and capture the statistical noise, measurement error and the second component capture the inefficiency. (Williams, 2004b).

To estimate cost efficiency, functional forms are used which include translog functional form and Fourier flexible functional form. Translog form is the most popular in literature (A. Berger & Mester, 1997). According to Mester (2003), the difference in estimation results from the two functional forms is small. Therefore, we use the translog functional form in this paper to estimate the cost efficiency which is shown below:

$$lnTC = \alpha 0 + \sum_{j=1}^{2} \beta_{\mathrm{j}} lnQ_{\mathrm{j}} + \sum_{m=1}^{3} \gamma_{\mathrm{m}} lnP_{\mathrm{m}} + \frac{1}{2}\left[\sum_{j=1}^{2}\sum_{k=1}^{2} \delta_{\mathrm{jk}} lnQ_{\mathrm{j}} lnQ_{\mathrm{k}} + \sum_{m=1}^{3}\sum_{n=1}^{3} \eta_{\mathrm{mn}} lnP_{\mathrm{m}} lnP_{\mathrm{n}}\right] + \sum_{j=1}^{2}\sum_{m=1}^{3} \theta_{\mathrm{jm}} lnQ_{\mathrm{j}} lnP_{\mathrm{m}} + \sum_{l=1}^{3} \tau_{\mathrm{l}} Z_{\mathrm{l}} + \varepsilon \quad (4)$$

where TC is total operating costs, including interest costs and non-interest operating expenses. Cost efficiencies are estimated using two outputs (Q_i) and three inputs (P_j) in the translog cost function. The two outputs are loans (Q_1) and other earning assets (Q_2) which are commonly used in bank efficiency literature.(Altunbas et al., 2007; A. Berger & Mester, 1997; Willesson, 2015). We use three inputs including labour, capital and funds. The unit price of labour is measured by the total personnel expense divided by the number of employees. However, since the data on number of employees is missing for many banks, we use the ratio of personnel expense over total assets as proxy for price of labour (P_1). The unit price of physical capital is measured as the ratio of non-interest operating expense over the book value of total fixed assets (P_2). The unit cost of funds is measured by the total interest expenses divided by total interest-bearing funds (P_3). We also include environmental variables Z_l that account for cross-country heterogeneities that vary over time but not across banks within the same country. The control variables (Z_l) include GDP per capital (GDP), GDP growth rate (GDPG), inflation rate (INF) that account for macroeconomic factors and two variables accounting for difference in banking sector for each country including concentration of banking industry (CON) represented by the ratio of total assets of 5 largest banks to total assets of the whole sector and domestic credit provided by banking sector as % of GDP (CRE). Data on environmental variables are taken from World Bank data source. ε represents compound error term which consists of u_{it} – the inefficiency term and v_{it} – the random error term.

The total operating costs and input prices are normalised by the price of labour (P_1) in order to impose linear homogeneity on the model. The normalisation is applied to avoid doubling costs when all inputs prices are doubled (A. Berger & Mester, 1997). The empirical cost function is specified as follows:

$$ln\frac{TC_{\mathrm{it}}}{\mathrm{P}_1} = \alpha_0 + \sum_{i=1}^{2} \beta_{\mathrm{j}} lnQ_{\mathrm{j}} + \sum_{m=1}^{2} \gamma_{\mathrm{m}} ln\frac{P_{\mathrm{m}}}{\mathrm{P}_1} + \frac{1}{2}\left[\sum_{j=1}^{2}\sum_{k=1}^{2} \delta_{\mathrm{jk}} lnQ_{\mathrm{j}}\, lnQ_{\mathrm{k}} + \sum_{m=1}^{2}\sum_{n=1}^{2} \eta_{\mathrm{mn}} ln\frac{P_{\mathrm{m}}}{\mathrm{P}_1} ln\frac{P_{\mathrm{n}}}{\mathrm{P}_1}\right] + \sum_{j=1}^{2}\sum_{m=1}^{2} \theta_{\mathrm{jm}} lnQ_{\mathrm{j}} ln\frac{P_{\mathrm{m}}}{\mathrm{P}_1} + \sum_{l=1}^{3} \tau_{\mathrm{l}} Z_{\mathrm{l}} + u_{\mathrm{it}} + v_{\mathrm{it}} \quad (5)$$

In this paper, we apply the stochastic frontier model used for panel data which is developed by Kumhbakar et al (2014). This model separates the error term into four components. The first component captures the firm heterogeneity. The second and the third components capture persistent and time-invariant inefficiency and time varying inefficiency. The last component reflects random shocks (v_{it}).

3.5. *Data and methods*

Three equations are estimated using two-step system GMM. OLS approach was traditionally used by Berger & DeYoung (1997) and William (2004). However, OLS does not produce robust result as the lagged variables may correlate with the error term. The more recently used method is two-step system GMM which is applied for dynamic panel data to handle the above mentioned problem of OLS (Casu & Girardone, 2009; Fiordelisi et al., 2011; Luo et al., 2016). GMM produces unbiased and consistent estimation and handle the issue of potential endogeneity in the dynamics of bank risk, capital and efficiency. This method is useful and relevant for a sample with small number of periods and large number of cross-sections (Roodman, 2006). The results from both approaches are presented in order to make comparison and to see the consistency of findings.

Our sample includes data of 146 commercial banks in 5 countries of ASEAN region for the period from 2005 to 2015. Information on banks' financial statements were obtained from Bankscope. Our sample comprises 1404 observations of banks from Thailand, Malaysia, Philippines, Indonesia and Vietnam. Indonesia dominates the sample with more than 40% of observations (see Table 3).

Table 4 shows the correlation among main variables. Capital appears to have positive relationship to loan loss provision which is proxy for risk. Banks in general tend to raise capital as a response to higher risk of loan loss. This is the expected sign as capital is needed to absorb loss from credit risk. Cost efficiency indicates a negative association with risk. As risk of loan loss becomes higher, banks may need to increase costs to monitor loans or cost to handle bad loans. As a result, banks incur higher cost which decrease cost efficiency. The positive correlation between cost efficiency and capital is noted from the descriptive statistics. The sign indicates that banks with higher capital appear to be more cost efficient. Size exhibits negative relationship with both capital, risk and efficiency. The correlation suggests that large banks expose to lower risk, maintain less capital and less cost efficient as compared to smaller banks. Bank income diversification as proxied by HHI shows positive correlation with risk, capital, efficiency and size. The higher concentration of banking activities as reflected by higher HHI, the higher the risk of problem loans, the higher the level of capital as well as cost efficiency. It is common that higher concentration of a bank income in interest which mainly source from credit activities, the higher the risk of non-performing loans and banks have to reserve higher provision maintain higher capital to absorb the risk. The sign is consistent with the relationship between risk, capital and efficiency. However, the correlation among variables as shown in the descriptive statistics need to be confirmed through further test such as statistic causality test and supported by appropriate theory as shown in the below section.

Table 5 shows the descriptive statistics including mean and standard deviation of variables for the sample with 5 countries in ASEAN. From the descriptive statistics, it can be seen that the loan loss reserves over loan varies among countries in which Vietnam has the lowest level whereas Philippines shows the highest ratio. The result is surprising as banking system in Vietnam is less developed compared to that of other countries. However, as loan loss reserve is subject to management discretion, Vietnamese banks might have insufficient reserves for loan loss. Among the five countries, Thailand and Indonesia have higher level of capital and Malaysian banks maintain the lowest capital ratio. Banks in Philippines and Malaysia have higher HHI score, implying that banks in these two countries concentrate more on credit activities whereas Thai banks seem to have more diversified income.

Average cost efficiency of the 5 ASEAN countries is 84%. This result is slightly higher than the efficiency score estimated by a number of previous studies (71% in study of Mongid (2015), 74% in study of Mongid & Muazaroh (2017), 84% in the study of Nguyen Thi Lam Anh (2018)). The difference in the average efficiency score lies with the different period of study and country sample. Cost efficiency shows small variation among countries in which Indonesian banks are the most cost efficient and Malaysian banks are the least cost efficient. Malaysian banks appear to be more conservative and incurring more costs compared to other countries.

Zscore indicates the probability of being solvent and can be considered a proxy for risk of default. Malaysian banks have the highest Zscore and the lowest ratio of risk weighed assets over the total assets (RWATA) among the five countries. This result suggests low probability of insolvency and low level of risk for Malaysian banks. Vietnamese banks experience the lowest Zscore and highest RWATA signaling highest level of risk within the five countries, but having the lowest ratio of loan loss. These contrasting ratios confirm the fact that management of Vietnamese banks seems to provide inadequate reserves for loan losses. Malaysian banks seem to be of larger size than the remaining countries. Size might have effect on the level of capital, risk and efficiency which will be explored in the below section.

With regards to macroeconomic variables in Table 6, Vietnam has the highest average GDP growth and inflation rate, followed by Indonesia and Philippines while Malaysia has the lowest growth in the period studied. In terms of corruption, the average Corruption Perception Index shows that Philippines, Vietnam has the highest level of corruption and Malaysia is the least corrupted country within the 5 countries studied. Malaysia has the most concentrated banking sector among the 5 countries and Thailand has the least concentrated banking system. Domestic credit provided by banking sector shows very different result among the five countries. Malaysia, Thailand and Vietnam have relataive high proportion of credits provided by banks whereas the other two countries have lower access to banking credit.

4. Analysis of results

Results of coefficient estimates from equations (1)-(3) using two lags on risk, capital and cost efficiency are displayed in Table 7.

Management behavior of banks in ASEAN seems not clear as there is no statistically significant link between cost efficiency and risk in the first equation. Cost efficiency does not have causality associate with risk. Evidence of bad management hypothesis is not supported with data from ASEAN banks.

In the risk equation where risk is measured by loan loss reserves over gross loan, the coefficient of the sum of lagged capital is negative and significant. This suggests that after a decrease in capital, risk relating to non-performing loans will increase. This result seems to be consistent with moral hazard theory where thinly capitalised banks assume additional risk and Granger cause increase in loan loss provision.

We also find a negative statistically significant link between risk and size of banks. It is evidenced that risks are lower for larger banks as it may be easier for large banks to diversify its asset portfolio to reduce risk. A negative relationship between bank income diversification proxied by HHI and risk is found and significant. This evidence implies that banks in ASEAN countries with higher level of income diversification tend to have lower risk. Such evidence suggests the benefits of diversification. As risk measure is proxied by proportion of loan loss over total loans, the risk is mainly attributed to credit risk. Thus, income diversification will result in lower credit risk. However, the negative relationship is not supported by literature. Evidence from previous studies in developed countries shows that the shift to non-interest income as indication of income diversification increases bank risk (Stiroh, 2004, Lepetit et al, 2008). The difference in results is derived from the measure of risk. Such positive link found in this study signals the benefits of diversification in relation to credit risk whereas positive relation found in literature is related to risk measured by volatitity of earnings.

Macroeconomic variables do not exhibit statistically significant relationship to banking risk with the exception of credits provided by banks. It seems that when banks provide higher credit to the economy, banking risk increases as the probability of nonperforming loans goes up with credit expansion.

In the cost efficiency equation, the relationship between capital, risk and efficiency is not statistically significant. This result does not support either bad luck or cost skimping hypotheses as proposed in literature and evidenced in studies in developed countries. Risk and capital do not Granger cause a change in cost efficiency of banks in ASEAN 5 countries.

We find statistically positive and significant association between HHI and cost efficiency. HHI is a measure of income diversification where lower HHI reflect diversification and higher ratio shows concentration of income. It seems that as income diversification decreases, banks are likely to be more cost efficient. This is consistent with result of Fiordelisi (2011) on European banks. More specialised banks with lower level of diversification can benefit from economies of scale that allow banks to lower costs as compared to more diversified counterparts.

Cost efficiency appears to be explained by a number of macroeconomic variables including concentration of banking sector, GDP per capita and level of corruption. Positive link between efficiency and concentration index showing that banks are more cost efficient in more concentrated market. This finding is consistent with a number of studies including Maudos & Guevarra (2007), Koetter et al (2012), Casu & Girardone (2006), Ferreira (2012), Titko et al (2014). Banks appear to be more efficient in countries with higher level of GDP per capita. The result is consistent with the study of Thi My Phan, Daly, & Akhter (2016). The negative statistically significant link between corruption index and cost efficiency. It suggests that countries with less corruption have less efficient banks. This implication seems to be weird. The issue of corruption has been looked in to in a number of studies. Relevant studies in Asia indicate that corruption can improve bank lending efficiency through connection with major customers. Pan & Tian (2013) argue that in emerging market where relationship in business is of particular important and can be faciliated by corruption, bank connection encourages rent seeking between borrowers and lenders, thereby reduce information and monitoring costs. They found evidence that bank connection and corruption jointly enhance lending efficiency in Chinese banks. Another study of Mongid et al (2011) also finds evidence of positve relationship between corruption index, bank profitability and efficiency in ASEAN countries.

In CAP equation (Table 7), the sum of the coefficients on the lagged RISK coefficients is positive and significant. It is relatively clear that capital is more likely to be related to past credit risk ((Fiordelisi et al., 2011). According to Berger & DeYoung (1997), banks tend to replenish capital following the increase in nonperforming loans in order to better absorb credit risk.

We do not find causal relationship between capital and cost efficiency for the whole sample. However, when we consider the relationship in a subsample of more efficient banks which are institutions with lagged cost efficiencies higher than median, we observe the positive and significant relationship (Table 8). The increase in sum of the lagged coefficients of cost efficiency precedes the rise in bank capital. This finding is consistent with A. N. Berger & DeYoung (1997b), Fiordelisi et al (2011). Increase in cost efficiency through a reduction in operating costs will enhance bank capital through earnings. This can happen only for cost efficient banks as those banks have higher earnings that Granger cause capital to increase.

Size of banks do have inverse impact on capital which is consistent with finding of Fiordelisi (2011). The negative and significant correlation indicates that large banks tend to have lower level of capital.

There is positive and significant relationship between income diversification as proxied by HHI index and bank capital. Banks with higher income concentration tend to have higher level of capital.

As banks supply more credit to the economy proxied by the increase in domestic credit provided by banks as percentage of GDP, level of bank capital appears to decline as indicated by negative coefficient.

5. Robustness checks

5.1. Robustness check on the number of lags

To confirm the validity of our findings, we perform a number of robustness checks. The system of equations (1)-(3) includes two lagged periods for bank risk, capital and cost efficiency. We re-estimate the equations with three and four lags. Increase in number of lags reduce the number of observations. As shown in Table 9, the results of both 3 lags and 4 lags seem to be consistent with that of 2 lags. However, the inclusion of more lagged terms may weaken the significance of the estimated coefficients.

Table 9 shows the total coefficients of variables (sum of lags). The results appear consistent. All the three variables RISK (represented by LLOSS), capital and cost efficiency are affected significantly by previous years' data. Cost efficiency does not exhibit significant relationship with bank risk. The significance of this coefficient reduces as we increase the number of lags. The relationship between loan loss provision and lagged capital is negative and significant for different number of lags. This finding implies that increase in bank capital Granger cause a decline in level of risk with lower loan loss provision. The evidence of moral hazard is observed for the whole sample.

The impact of risk and capital on cost efficiency is not strong. Positive relationship between the lagged credit risk and cost efficiency is seen when two lags are used in the model and the coefficient is rather small. As the number of lags increases, the coefficient is no longer significant. The level of income diversification, concentration of banking sector, and GDP indicate impact on bank cost efficiency with consistent and significant results across the number of lags in the model.

Cost efficiency does not exhibit any causal relationship with bank capitalisation. The lagged risk is positively correlated with capital regardless of number of lags in the equations and statistically significant at 1%. Level of risk in the past clearly Granger causes the change in bank capital.

5.2. Robustness on the measure of risk

Bank risk has been widely discussed in literature and appropriate measure of bank risk is still under discussion. Literature suggests several alternatives. The ratio of non-performing loans over gross loan is commonly used in literature which measures the credit risk of banks. (A. N. Berger & DeYoung, 1997a; Fiordelisi et al., 2011; Kwan & Eisenbeis, 1997). Similarly, the ratio of loan loss reserve over gross loan - a similar proxy for credit risk is also popular (Altunbas et al., 2007; Tan & Floros, 2013; Williams, 2004b). This measure has limitation of being affected by management discretion. However, the data is available with this measure since it derives from accounting figures.

Some others use the ratio of risk weighted assets over total assets to measure portfolio risk of banks (Rime, 2001). This risk measure reflects bank decisions on risk taking, but weighting risk correctly across different asset categories can be problematic.
Another measure of risk which has been adopted by many researchers is Zscore, which reflects the probability of a bank's insolvency risk. Z-score is widely used in banking literature as a measure of risk (Luo et al., 2016; Willesson, 2015). It is also used by the World Bank in their Global Financial Development Database to measure financial institution soundness.

Z-score is initially used by Hannan and Hanweck (1988) and Boyd et al. (1993). Z-score is commonly used in panel study because of their relative simplicity, availability since it derives from accounting data as well as its relative explanatory power of insolvency risk. We adopt Z-score as another measure of risk in our study to check the robustness of our estimation result.

$$Z - score = \frac{ROA + E/A}{\sigma_{\mathrm{ROA}}}$$

Z-score can be calculated using current ROA and E/A with 3-year rolling window standard deviation of ROA which is the most common way in literature. (Lepetit & Strobel, 2013; Willesson, 2015). However, this approach of calculating Z-score will limit the number of usable observations and the score exposes to wide variation. Another way of getting Z-score is to use mean and standard deviation of the return on assets for the whole period combined with the current value of capital-asset ratio. According to Lepetit & Strobel (2013), this measure of Z-score exhibits low level of inter-temporal volatility on individual bank basis and produces consistent results. We adopt this method of determining Z-score. According to Laeven and Levine (2009), Z-score measure is highly skewed, then the natural logarithm is commonly used. In this robustness check, we use the natural logarithm of Z-score as a proxy for risk. The higher value of Z-score, the lower a bank insolvency risk.

Table 10 reports results obtained from estimating 3 equations using two different risk measures which are risk weighted assets over total assets (RWATA) and Zscore as compared to the initial proxy of loan loss reserves over loan. Conflicting signal on the impact of lagged efficiency on risk is observed for the first equation. The use of RWATA to capture bank risk supports bad management behavior with negative relationship whereas the use of Zscore implies that lower efficiency precedes higher Zscore which is lowering risk. The impact of lagged risk on efficiency and lagged efficiency on capital is not statistically significant.

However, the effects of control variables on risk, efficiency and capital are consistent among the three different measures of risk.

5.3. Robustness check on measure of efficiency

We also re-test the behavior of banks for evidence of bad management, bad luck or skimping using estimated profit efficiency (Table 11). The result does not yield any significant evidence of bank behaviour.

6. Conclusion

This paper assesses the inter-temporal relationships among bank risk, capital and efficiency for commercial banks in five ASEAN countries. The study is built upon intial work of bank behaviour theories of Berger & De Young (1997) using Granger causality test in a panel data framework and contributes to literature as a test for banks in ASEAN market. Our model focuses on the causal relationship between bank efficiency (proxied by cost efficiency or profit efficiency), bank risk (proxied by non-performing loans or risk weighted assets or Zscore) and bank capital (proxied by total capital ratio).

In general, our result does not find evidence to support bad management, bad luck or cost skimping hypotheses. Moral hazard hypothesis is supported when a decrease in capital precedes or Granger cause an increase in risk of loan loss. The bi-directional causal link between capital and risk is significant with accounting measure of risk only (loan loss reverse/gross loan). The evidence is weak for other proxies such as risk weighted assets to total assets or Zscore. However, causal link between cost efficiency and capital is found for the subsample of more efficient banks. For those banks, increase in cost efficiency Granger cause the increase in capital through probably higher earnings.

Size does have negative impact on the level of risk and capital of banks in general. Larger banks tend to maintain less capital and less risk as they can raise capital rather easily and diversify their asset portfolio to lower risks. Bank income diversification indicated by HHI presents relatiionship with risk, capital and cost efficiency. Banks in ASEAN 5 with higher level of income diversification tend to have higher risk, lower cost efficiency and lower level of capital. Macroeconomic variables tend to statistically affect cost efficiency rather than risk or capital.

Overall, we believe that our results can be interesting for financial institutions in understanding factors that might cause the change in cost efficiency. Bank efficiency can be decomposed to study the determinants. The result of this study can have certain implications for bank supervisors and regulators when moral hazard behavior is evidenced in banks in ASEAN countries. From regulatory perspective, it is necessary for banks, particularly thinly capitalised banks to maintain adequate level of capital.

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APPENDICES

Table 1: Summary of empirical studies on risk, capital and efficiency

Authors	Year	Sample	Efficiency measure	Method	Impact of efficiency on risk	Impact of efficiency on cap	Relation cap & risk
Kwan, S. and Eisenbeis, R.,	1997	US 1986-1991	SFA	2SLS	- less efficient banks have higher risk in risk equation + less efficient banks have less rik in efficiency equation	+ better capitalised banks are more efficient	
Berger & DeYoung	1997	US 1985-1994	SFA	Granger causality	- risk & efficiency: bad management & bad luck	+ inefficient banks have low capital	- thinly capitalised banks take on more risk
William	2004	EU 1990-1998	SFA	Granger causality	- risk & efficiency: bad management in Germany, Denmark, whole sample	- decrease in cost efficiency cause increase in capitalisation for German & Spanish banks	no relation is identified
Das & Ghosh	2004	Indian 1993-2001	SFA	2SLS	- more efficient banks take on less risk	- for large banks: better capitalised banks are less efficient + for small banks: better capitalised banks are more efficient	- better capitalised banks take on less risk

Altunbas et al	2007	EU banks 1992-2000	SFA	SUR	+ more efficient banks take on more risk - for least efficient banks takes on more risk	- less efficient banks hold more capital + for co-opearative banks	+ for commercial & saving banks, for least efficient banks - for cooperative banks, for most efficient banks
Deelchand & Paggett	2009	Japanese cooperative banks 2003-2006	SFA	2SLS	- less efficient banks have higher risk in risk equation	- better capitalised banks are less efficient	- better capitalised banks take on less risk
Mongid, Tahir, Haron	2012	ASEAN 2003-2008	CIR	3SLS	+ more efficient banks take on more risk	+ better capitalised banks are more efficient	- better capitalised banks take on less risk
Tan & Floros	2013	Chinese banks 2003-2009	SFA	3SLS	+ LLPTL & efficiency		- Zscore & cap
Tahir, Mongid	2013	ASEAN 2003-2008	SFA	3SLS	+ more efficient banks take on more risk	+ better capitalised banks are more efficient	- better capitalised banks take on less risk
Manta, Badircea	2015	Romania 2008-2011	DEA	Pooled least square	+ more efficient banks assume more risk if risk is measured by nonperforming loans	- less efficient banks hold more capital	+ banks with higher risk hold more capital
Bashir, Hassan	2017	Pakistan 1997-2015	CIR	GMM	+ more efficient banks take on more risk	- better capitalised banks are less efficient	- better capitalised banks take on less risk

Table 2 : Variables used in the model

Variable	Variable name	Description
Endogenous variable		
CAP	Capital	Ratio of total capital to total asset
LLOSS	Risk measure	Ratio of provision of loan loss over total loans
CE	Cost efficiency	Cost efficiency score measured using SFA
Bank specific variable		
SIZE	Size of bank	Natural log of total assets
HHI	Bank income diversification	Formula presented in text
Country specific variable		
CON	Concentration ratio	Ratio of 5 largest banks over the whole bank sector (Source: Worldbank)
CRE	Banking credit ratio	domestic credit provided by banks in the economy (Source: Worldbank)
GDP	GDP growth	GDP growth rate of a country (Source: Worldbank)
INF	Inflation rate	Inflation rate of a country (Source: Worldbank)
CORR	Corruption perception index	Corruption index of a country (Source: transparency.org)

Table 3: Sample component

Country	No of banks	% of the sample	No of observations	% of the sample
Thailand	18	12%	191	14%
Malaysia	18	12%	183	13%
Philippines	26	18%	241	17%
Indonesia	60	41%	585	42%
Vietnam	24	16%	204	15%
Total	**146**	**100%**	**1404**	**100%**

Table 4: Correlation among variables

	LLOSS	CAP	CE	SIZE	HHI
LLOSS	1				
CAP	0.1038	1			
CE	-0.2575	0.2011	1		
SIZE	-0.0933	-0.453	-0.0376	1	
HHI	0.0099	0.0211	0.067	0.0221	1

Table 5: Descriptive statistics

Variable	**No of obs**	**LLOSS**	**CAP**	**HHI**	**CE**	**Zscore**	**RWATA**	**SIZE**
Whole sample	1404	3.50	12.14	0.22	0.84	29.90	0.65	14.89
Thailand	191	4.06	13.56	0.24	0.85	32.85	0.66	15.99
Malaysia	183	3.00	9.05	0.51	0.81	43.93	0.54	16.31
Philippines	241	7.76	12.26	0.51	0.81	26.91	0.70	14.56
Indonesia	585	2.59	13.14	0.32	0.86	28.24	0.65	14.22
Vietnam	204	1.31	10.56	0.33	0.85	22.86	0.71	14.90

Table 6 : Descriptive statistics – control variables by country

Control variables	**Indonesia**	**Malaysia**	**Philipplines**	**Thailand**	**Vietnam**
CORR	29.16	48.60	28.48	35.68	28.52
CRE	39.54 (36)	125.88 (80)	50.81 (31)	138.46 (78)	101.14 (31)
GDPG	5.63	4.94	5.36	3.42	6.07
INF	6.83	2.60	4.38	2.69	9.92
CON	66.17	81.24	61.27	57.15	61.96

Table 7: Granger causality for the relationship among bank risk, capital and cost efficiency

Variable	Equation 1: LLOSS			Equation 2: CE			Equation 3: CAP		
	Coefficient	p value		Coefficient	p value		Coefficient	p value	
LLOSS									
L1.	0.655	-	***	-0.000	0.707		0.215	0.044	**
L2.	0.162	0.133		0.001	0.239		-0.065	0.500	
LLOSS$_{total}$	0.816	-	***	0.000	0.404		0.151	0.001	***
CAP									
L1.	-0.039	0.096	*	0.001	0.126		0.423	-	***
L2.	-0.002	0.952		-0.001	0.143		0.153	0.093	*
CAP$_{total}$	-0.041	0.009	***	0.000	0.683		0.576	-	***
CE									
L1.	17.688	0.086	*	0.629	-	***	19.928	0.213	
L2.	-11.608	0.003	***	0.169	0.010	***	-12.271	0.116	
CE$_{total}$	6.080	0.530		0.798	-	***	7.657	0.548	
SIZE	-0.108	0.079	**	0.001	0.589		-0.407	0.004	***
HHI	-0.009	0.015	**	0.001	-	***	0.034	-	***
CON	0.004	0.600		0.000	0.005	***	0.003	0.792	
GDP	-0.000	0.172		0.000	0.005	***	0.000	0.249	
INF	-0.015	0.749		0.000	0.865		0.038	0.448	
CORR	0.019	0.309		-0.002	-	***	-0.010	0.780	
CRE	0.003	0.039	**	-0.000	0.903		-0.010	0.026	**
Yr3	-3.365	0.685		-0.009	0.078		3.744	0.744	
Yr4	-3.338	0.679		-			3.012	0.790	
Yr5	-3.090	0.711		-0.004	0.456		4.067	0.724	
Yr6	-3.126	0.707		-0.006	0.172		4.127	0.718	
Yr7	-3.544	0.668		-0.006	0.128		4.222	0.711	
Yr8	-3.569	0.670		-0.002	0.655		4.674	0.682	
Yr9	-3.429	0.682		0.004	0.319		4.456	0.699	
Yr10	-3.509	0.680		-0.001	0.795		4.480	0.700	
Yr11	-3.047	0.723		-0.000	0.963		5.392	0.639	
Observations		1086			1089			1089	
Hansen test									
p value		0.102			0.104			0.45	
AB test AR(1)		0.207			0.005			0.021	
AB test AR(2)		0.583			0.735			0.518	

*** Statistically significant at 1%
** Statistically significant at 5%
* Statistically significant at 10%

Table 8: Granger causality in capital equation (3)- subsample of more efficient banks

Variable	Equation 3: CAP Coefficient	p value	
LLOSS			
L1.	0.521	0.275	
L2.	-0.305	0.528	
$LLOSS_{total}$	0.217	-	***
CAP			
L1.	0.443	-	***
L2.	0.067	0.506	
CAP_{total}	0.510	-	***
CE			
L1.	66.026	-	***
L2.	-1.287	0.898	
CE_{total}	64.739	-	***
SIZE	-0.852	0.001	***
HHI	4.378	0.020	**
CON	-0.195	0.021	**
GDP	0.001	0.009	***
INF	0.052	0.039	**
CORR	0.123	0.105	
CRE	-0.008	0.248	
Observations		560	
Hansen test			
p value		0.139	
AB test AR(1)		0.054	
AB test AR(2)		0.235	

Table 9: Robustness check for number of lags under twostep system GMM

	Number of lags		
	2 lags	**3 lags**	**4 lags**
Eq 1 - Dependent variable = LLOSS			
$LLOSS_{total}$	0.816***	0.7112***	0.7949***
CAP_{total}	-0.041***	-0.0504	0.0058
CE_{total}	6.08	8.2534	8.3411
SIZE	-0.108*	-0.0725	-0.0102
HHI	-0.009**	-0.0108**	0.367
CON	0.004	0.0215*	0.0062
GDP	0.000	-0.0002**	-0.0001
INF	-0.015	-0.0585	0.0099
CORR	0.019	0.0552	0.0406
CRE	0.003**	0.0013	0.0025
Eq 2 - Dependent variable = CE			
$LLOSS_{total}$	0.0004	-0.0002	-0.0002
CAP_{total}	0.0002	0.0008	-0.0011
CE_{total}	0.798***	0.7924***	0.8204***
SIZE	0.001	0.0010	- 0.0001
HHI	0.001***	0.0005***	-0.0140
CON	0.0003***	0.0004***	0.0003***
GDP	0.0000***	0.0000**	0.0000
INF	0.0001	0.0003	0.0003
CORR	-0.002***	-0.0013***	-0.0012
CRE	-0.0000	-0.0000	-0.0000
Eq 3 - Dependent variable = CAP			
$LLOSS_{total}$	0.151***	0.1999***	0.1936**
CAP_{total}	0.576***	0.7488***	0.6355***
CE_{total}	7.657	12.067	-2.984
SIZE	-0.407***	-0.3138**	-0.4844***
HHI	0.034***	0.0326***	0.6011
CON	0.003	-0.0089	-0.0011
GDP	0.000	0.0001*	0.0003*
INF	0.038	0.0742*	0.1051**
CORR	-0.010	-0.0009	-0.0858
CRE	-0.010	-0.0006*	-0.0062

Table 10: Robustness check - different measures of risk

	RISK EQUATION			EFFICIENCY EQUATION			CAPITAL EQUATION		
	RISK=LLOSS	RISK=RWATA	RISK=ZSCORE	RISK=LLOSS	RISK=RWATA	RISK=ZSCORE	RISK=LLOSS	RISK=RWATA	RISK=ZSCORE
RISK									
L1.	0.655 ***	0.331 **	0.809 ***	-0.000	-0.002	-0.012	0.215 **	-1.598	0.422
L2.	0.162	0.068	0.087	0.001	-0.014	0.010	-0.065	1.047	-0.196
RISK_{total}	0.816 ***	0.399 ***	0.897 ***	0.000	-0.016	-0.002	0.151 ***	-0.551	0.226
CAP									
L1.	-0.039 *	0.003	-0.006	0.001	0.000	0.001	0.423 ***	0.740 ***	0.523 ***
L2.	-0.002	-0.001	-0.006	-0.001	0.000	-0.000	0.153 *	0.011	0.044
CAP_{total}	-0.041 ***	0.002	-0.011 *	0.000	0.001	0.000	0.576 ***	0.751 ***	0.566 ***
CE									
L1.	17.688 *	-0.713	1.256	0.629 ***	0.741 ***	0.620 ***	19.928	4.584	6.731
L2.	-11.608 ***	0.094	-1.432 **	0.169 ***	0.095	0.100	-12.271	-5.835	-2.673
CE_{total}	6.080	-0.619	-0.176	0.798 ***	0.837 ***	0.720 ***	7.657	-1.251	4.057
SIZE	-0.108 *	-0.005	-0.005	0.001	0.001	0.001	-0.407 ***	-0.260 **	-0.434 *
HHI	-0.009 **	0.004 ***	0.015 ***	0.001 ***	0.000 ***	0.001 ***	0.034 ***	0.034 **	0.033 ***
CON	0.004	-0.001 **	-0.000	0.000 ***	0.000 ***	0.000 **	0.003	-0.005	-0.000
GDP	-0.000	-0.000	0.000 *	0.000 ***	0.000 ***	0.000 ***	0.000	0.000	0.000
INF	-0.015	0.000	0.003	0.000	0.000	0.000	0.038	0.013	0.002
CORR	0.019	0.000	-0.000	-0.002 ***	-0.001 ***	-0.002 ***	-0.010	-0.025	-0.012
CRE	0.003 **	0.000	-0.001	-0.000	0.000	0.000	-0.010 **	-0.006 *	-0.008
Yr3	-3.365	1.022	-	-0.009	0.131	0.240	3.744	-0.893	7.407
Yr4	-3.338	1.026	-0.060	-	0.141	0.245	3.012	-2.056	7.181
Yr5	-3.090	1.020	0.018	-0.004	0.133	0.240	4.067	-0.697	7.623
Yr6	-3.126	1.070	0.023	-0.006	0.137	0.242	4.127	-0.973	7.594
Yr7	-3.544	1.068	0.001	-0.006	0.136	0.241	4.222	-1.064	7.793
Yr8	-3.569	1.070	0.038	-0.002	0.140	0.247	4.674	-0.702	8.239
Yr9	-3.429	1.077	-0.007	0.004	0.144	0.251	4.456	-0.925	7.939
Yr10	-3.509	1.082	-0.034	-0.001	0.138	0.244	4.480	-0.728	8.143
Yr11	-3.047	1.079	0.043	-0.000	0.141	0.246	5.392	-	8.950
_cons	-	0.443	0.679	0.182	-	-	-	10.176	-

Table 11 - Result with profit efficiency (PE)

Variable	Equation 1: LLOSS Coeff	p value		Equation 2: PE Coeff	p value		Equation 3: CAP Coeff	p value	
LLOSS									
L1.	0.541	-	***	0.003	0.512		0.067	0.578	
L2.	0.223	0.042	**	- 0.002	0.219		0.036	0.695	
$LLOSS_{total}$	0.764	-	***	0.000	0.959		0.103	0.354	
CAP									
L1.	- 0.019	0.580		0.003	0.188		0.423	-	***
L2.	- 0.014	0.462		- 0.000	0.908		0.103	0.157	
CAP_{total}	- 0.034	0.207		0.003	0.062	*	0.526	-	***
PE									
L1.	3.555	0.268		0.471	0.011	**	9.745	0.462	
L2.	- 1.574	0.259		0.022	0.870		- 3.349	0.616	
PE_{total}	1.981	0.479		0.493	-	***	6.395	0.372	
SIZE	- 0.075	0.413		0.003	0.348		- 0.542	0.013	**
HHI	- 0.004	0.101		0.000	0.039	**	0.035	-	***
CORR	- 0.019	0.438		0.001	0.240	***	- 0.052	0.373	
GDP	- 0.000	0.728		- 0.000	0.335	***	0.000	0.209	
CON	0.006	0.258		- 0.000	0.514		0.005	0.726	
INF	- 0.002	0.951		- 0.002	0.161	***	0.011	0.847	
CRE	0.004	0.058	*	- 0.000	0.514		- 0.008	0.099	*
Observations		1,072			1,068			1,075	
Hansen p value		0.348			0.093			0.535	
AB test AR(1)		0.241			0.020			0.012	
AB test AR(2)		0.398			0.317			0.346	