MACROPRUDENTIAL STRESS TESTING FOR CREDIT RISK: EMPIRICAL EVIDENCE FROM THE THAI HOUSING LOAN

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Abstract

This study aims to assess credit risk regulatory capital requirement under a stress scenario of non-performing housing loan during 2013-2014. Therefore, this paper uses Vector Autoregressive (VAR) model to analyze the impact of macroprudential policies and macroeconomic environment on credit risk of housing loan. The result indicates that macroeconomic factors; e.g., gross domestic product (GDP) and consumer price index (CPI) have a significant negative impact on non-performing loan (NPL). Furthermore, the result also suggests that loan-to-value (LTV) ratio as a macroprudential instrument is correlated with a change in non-performing housing loan. The deceasing of the past four period LTV ratio generates non-performing housing loan of the current period. The regulator should therefore effectively deploy macroprudential policies to slowdown the NPL and create financial stability, thus securing the resilience of the financial system. This study also found that the Bank of Thailand has overestimated the loan provision requirement of 1.00 percent of total outstanding debt. In addition, the study reveals that under a stress the Thai commercial bank should increase loan-loss provision level when an economic downturn sets in. Under a stress and economic crisis this study shows that value-at-risk (VaR) is not the proper approach to determine the regulatory credit risk capital. Therefore, conditional value-at-risk (CVaR) may represent an additional insight for estimating capital buffer from severe credit risk especially under systemic risk environment. Additional capital buffer of 0.0044-0.0064 percent of credit housing loan is also required to enhance bank's financial stability under a stress scenario.

Keywords: Credit Risk, Probability of Default, Macroprudential Policy, Capital, NPL

บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อ ประเมินเงินกองทุนของตวามเสี่ยงด้านเครดิตของสินเชื่อเพื่อที่อยู่อาศัยของประเทศไทยภายใต้ภาวะวิกฤติ ตามนโยบายมหภาคแบบรอบคอบ ในช่วงเวลา ปีค.ศ. 2013-2014 รวมทั้งวิเคราะห์นโยบายมหภาคแบบรอบคอบที่ให้ความสำคัญกับสัดส่วนการให้สินเชื่อต่อมูลค่าหลักประกัน โดยวิเคราะห์ร่วมกับกับตัวแปรเศรษฐกิจมหภาคคือ ผลิตภัณฑ์มวลรวมภายในประเทศ ดัชนีราคาผู้บริโภค ดัชนีบ้านเดี่ยวพร้อมที่ดิน ที่ส่งผลต่อหนี้ที่ไม่ก่อให้เกิดรายได้ของสินเชื่อเพื่อที่อยู่อาศัย การศึกษานี้ได้ใช้แบบจำลอง Vector Autoregressive (VAR) และใช้การวัดมูลค่าความเสี่ยง (VaR) และการวัดมูลค่าความเสี่ยงแบบมีเงื่อนไข (CVaR) เพื่อประเมินเงินกองทุนของความเสี่ยงด้านเครดิต และประเมินเงินกองทุนส่วนเพิ่ม ภายใต้ภาวะวิกฤติตามนโยบายมหภาคแบบรอบคอบ ผลการศึกษาชี้ให้เห็นว่า การกำหนดอัตราส่วนการให้สินเชื่อต่อหลักประกัน มีความสัมพันธ์กับการเปลี่ยนแปลงของหนี้ที่ไม่ก่อให้เกิดรายได้ของสินเชื่อเพื่อที่

อยู่อาศัย โดยเมื่อสัดส่วนของการให้สินเชื่อต่อหลักประกันมีค่าลดลงผ่านไปสี่ไตรมาส จะส่งผลให้หนี้ที่ไม่ก่อให้เกิดรายได้ของสินเชื่อเพื่อที่อยู่อาศัยในไตรมาสปัจจุบันลดลงมากที่สุด นอกจากนี้ งานวิจัยนี้ยังชี้ให้เห็นว่า การกันสำรองของลูกหนี้ปกติที่ธนาคารแห่งประเทศไทยกำหนดในปัจจุบันคือร้อยละ 1.00 ของยอดหนี้ทั้งหมดนั้น เป็นการกันสำรองที่สูงเกินกว่าความเสี่ยงที่แท้จริง สำหรับการดำรงเงินกองทุนของความเสี่ยงด้านเครดิตนั้น งานวิจัยนี้แสดงให้เห็นว่า การใช้วิธีการประเมินมูลค่าความเสี่ยงนั้น ไม่มีความเหมาะสมต่อการกำกับดูแลเงินกองทุนของความเสี่ยงด้านเครดิตเมื่อเกิดภาวะวิกฤติ เนื่องจากมูลค่าความเสี่ยงสูงสุดมีค่าเกินกว่ามูลค่าความเสี่ยงเป็นจำนวนมาก ทำให้ธนาคารต้องดำรงเงินกองทุนส่วนเพิ่มอีกร้อยละ 0.0044 ถึงร้อยละ 0.0064 ของยอดหนี้สินเชื่อเพื่อที่อยู่อาศัย ในไตรมาสที่ 1 และ 2 ของปี คศ. 2014

INTRODUCTION

Financial institution is the medium role of asset allocation. The efficiency of financial system will contribute economic growth. This would be successful under two main factors: 1) the stability of each financial institution and 2) the optimality of the fundamental financial institution system.

Financial system consists of many types of financial institutions such as commercial bank--the largest provider, capital financial institution, state-owned commercial bank, security company, and insurance company. However, the commercial bank is an important part of the financial system and has a close relationship with the economy. Commercial banks can be severely affected from a depressed economy, and vice versa.

In the recent years, there are many financial crisis or cascade of financial institution failures affecting the economy and creating economic cost (output cost). The latest financial crisis, the subprime-mortgage crisis, is a solid example to point out the economic risk caused by the high linkage across the financial institution; i.e., "Systemically Important Financial Institutions (SIFIs))". Thus, the regulator would essentially develop the policy tool to enhance the efficiency of regulatory framework to mitigate risk to the financial system as a whole (systemic risk). Microprudential policy only is not concrete enough since it is a firm-level oversight by regulators to ensure that the balance sheets of individual institutions are robust to shocks. This perspective is opposed to the macroprudential view which focuses on welfare of the entire financial system (Borio, 2003). Macroprudential policy was introduced by the Basel Committee (BASEL) to maintain the balance between the stability of monetary policy and financial institution. Several aspects of the BASEL III reflect a macroprudential approach to financial regulation (Borio, 2011). The macroprudential policy ultimately aims to prevent and mitigate systemic risk, which includes strengthening the resilience of financial system. This particular policy focuses on smoothening the financial cycle avoiding that it reaches a dangerous peak (European Central Bank, 2016). Various instruments have been employed to measure credit-related, liquidity-related, and capital-related types in order to achieve macroprudential objectives (Lim et al., 2011). The macropudential regulation requires banks to have set aside enough capital and capital buffer to cover unexpected loss and keep themselves financial solvent in a crisis. Caps on loan to value should be an important additional ingredients in the macroprudential policy framework to measure the credit flows and to address risks in a country's real estate market (Shin, 2010 and European Central Bank, 2016).

Bank of Thailand announced a new policy of housing loan portfolio for commercial banking. Loan-to-value (LTV) ratio is employed as a macroprudential tool to limit the loan exposure.

This policy is used to reduce the overheated speculation in the residential high-rise and reduce the bubbles in the real estate sector. This policy will affect the capital adequacy ratio (BIS ratio) and it is a mechanism to increase the concentration of the bank's risk management performance. Figure 1 below indicates that the quarterly change in gross domestic product (GDP) since the 1st quarter of 2002 was lower to the change in the housing outstanding loan for the whole studying period. So, it is interesting to study the impact of macroprudential policy on the stability of financial institutions.

Figure 1: Thailand's Gross Domestic Product and Housing Outstanding Loan

Source: Bank of Thailand and Office of National Economic and Social Development Board

Therefore, this paper describes a model to test the efficiency of macroprudential policy and conducts stress test for Thailand housing loan portfolio. The first section explores the relationship and impact of macroprudential policy, represented by the ratio of the loan-to-value (LTV), and macroeconomic variables--gross domestic product (GDP), consumer price index (CPI) and the housing price index (HPI), on housing loan portfolio's probability of default. The second part reveals an assessing and stress testing on the capital adequacy for housing loan credit risk of the Thai banking system.

THEORETICAL FRAMEWORKS AND LITERATURE REVIEWS

This research is based on conceptual framework of banking sector financial instability that can amplify and propagate business cycle. Zhang (2009) used the model builds on Bernanke, Gertler and Gilchrist (BGG) (1999) considering credit demand friction due to agency cost. Financial intermediaries have to share aggregate risk with entrepreneurs and therefore bear uncertainty in their loan portfolios if there is a case of any deviation. Unexpected aggregate shocks will drive loan default rate away from expected, and have an impact on both firm and bank's balance sheet via the financial contract. Low bank capital position can create strong credit supply contraction, and have a significant effect on business cycle dynamics. Therefore, it is necessary to create a macroprudential policy framework and tool to mitigate the unexpected aggregate shock. Macroprudential policy can be divided into two types. First is a macroprudential indicator which is mainly driven by the jump increase in the assets of commercial banks. It can be measured by the ratio of total loans to gross domestic product.

Moreover, if the financial institution is raising secondary source of fund (The central bank uses monetary policy to drive economy) which may affect inflation rate. This can cause economy instability. Second is a macroprudential policy which can help to alleviate the instability of financial institutions and to minimize the impact on economy (economic externalities).

Credit portfolio model is then used to assess housing loan portfolio risk. Three factors which are 1) probability of default (PD), a Bernoulli distribution, and 2) loss given default (LGD), percentage of the loss that may have occurred when the event defaults and 3) exposure at default (EAD), are used to estimate total outstanding debt on the default event. The valuation of the credit risk is done via a calculation of expected loss (EL) and unexpected loss (UL). Commercial bank should set the provision to support EL. However, banks could still experience unexpected credit loss exceeding the expected level. The amount of UL of housing loan is capital requirement that bank must hold due to the susceptibility of credit risk. The capital requirement can be estimated from the difference between the value-at-risk (VaR) and EL.

Stress testing of credit risk is necessary to further conduct and assess the impact of external factors which can generate an adverse effect on loan portfolio status and portfolio quality or PD. Typically, macro stress test of credit risk involves three major tasks which are 1) the development of a model to capture the interrelationship between selected macroeconomics and financial variables, 2) the calibration of parameter vectors linking macroeconomic and financial variables to specific measures of loan performance, and 3) the design of adverse macroeconomics scenarios and the computation of the impacts on credit quality and bank's financial solvency.

RESEARCH METHOD

The stress test framework presented in this paper comprises two components. Therefore, to find the effect of macroprudential policies, represented by LTV ratio, and macroeconomic variables on loan repaying capability this research analyzed such an impact by using Vector Autoregressive (VAR) model. Thus testing Stationary of variables is important which is done through a unit root test by using Augmented Dickey-Fuller test and the unit root test and the equations are shown below.

$$\Delta X_t = \theta X_{t-1} + \sum_{t=1}^{p} \phi_t \Delta X_{t-1} + \varepsilon_t \qquad \text{none} \qquad (1)$$

$$\Delta X_t = \alpha_0 + \theta X_{t-1} + \sum_{t=1}^{p} \phi_t \Delta X_{t-1} + \varepsilon_t \qquad \text{with intercept} \qquad (2)$$

$$\Delta X_t = \alpha_0 + \theta X_{t-1} + \gamma t + \sum_{t=1}^{p} \phi_t \Delta X_{t-1} + \varepsilon_t \qquad \text{with intercept and trend} \qquad (3)$$

The Augmented dickey – Fuller Test hypotheses are as follows:

$H_{0:}$ $\theta = 0$ Non-stationary
$H_{1:}$ $\theta < 0$ Stationary

Then this study analyze a long-term equilibrium relationship (cointegration) as mentioned above using Vector Autoregressive (VAR). VAR approach, developed by Sims (1980), treats every endogenous variable in the system as function of the lagged length of all of the endogenous variables in the system. The VAR equation is estimated the ordinary least square regressions as shown in equation (4) to equation (9).

$$\begin{aligned}
\mathrm{NPL_t} &= a_1 + \textstyle\sum_{i=1}^{n} A_{1i}\,\mathrm{NPL_{t-i}} + \sum_{i=1}^{n} B_{1i}\,\mathrm{GDP_{t-i}} + \sum_{i=1}^{n} C_{1i}\,\mathrm{CPI_{t-i}} \\
&\quad + \textstyle\sum_{i=1}^{n} D_{1i}\,\mathrm{HPI_{t-i}} + \sum_{i=1}^{n} E_{1i}\,\mathrm{LTV_{t-i}} + \sum_{i=1}^{n} F_{1i}\,\mathrm{DUM_{t-i}} + \epsilon_{1t} \qquad (4)\\
\mathrm{GDP_t} &= a_2 + \textstyle\sum_{i=1}^{n} A_{2i}\,\mathrm{NPL_{t-i}} + \sum_{i=1}^{n} B_{2i}\,\mathrm{GDP_{t-i}} + \sum_{i=1}^{n} C_{2i}\,\mathrm{CPI_{t-i}} \\
&\quad + \textstyle\sum_{i=1}^{n} D_{2i}\,\mathrm{HPI_{t-i}} + \sum_{i=1}^{n} E_{2i}\,\mathrm{LTV_{t-i}} + \sum_{i=1}^{n} F_{2i}\,\mathrm{DUM_{t-i}} + \epsilon_{2t} \qquad (5)\\
\mathrm{CPI_t} &= a_3 + \textstyle\sum_{i=1}^{n} A_{3i}\,\mathrm{NPL_{t-i}} + \sum_{i=1}^{n} B_{3i}\,\mathrm{GDP_{t-i}} + \sum_{i=1}^{n} C_{3i}\,\mathrm{CPI_{t-i}} \\
&\quad + \textstyle\sum_{i=1}^{n} D_{3i}\,\mathrm{HPI_{t-i}} + \sum_{i=1}^{n} E_{3i}\,\mathrm{LTV_{t-i}} + \sum_{i=1}^{n} F_{3i}\,\mathrm{DUM_{t-i}} + \epsilon_{3t} \qquad (6)\\
\mathrm{HPI_t} &= a_4 + \textstyle\sum_{i=1}^{n} A_{4i}\,\mathrm{NPL_{t-i}} + \sum_{i=1}^{n} B_{4i}\,\mathrm{GDP_{t-i}} + \sum_{i=1}^{n} C_{4i}\,\mathrm{CPI_{t-i}} \\
&\quad + \textstyle\sum_{i=1}^{n} D_{4i}\,\mathrm{HPI_{t-i}} + \sum_{i=1}^{n} E_{4i}\,\mathrm{LTV_{t-i}} + \sum_{i=1}^{n} F_{4i}\,\mathrm{DUM_{t-i}} + \epsilon_{4t} \qquad (7)\\
\mathrm{LTV_t} &= a_5 + \textstyle\sum_{i=1}^{n} A_{5i}\,\mathrm{NPL_{t-i}} + \sum_{i=1}^{n} B_{5i}\,\mathrm{GDP_{t-i}} + \sum_{i=1}^{n} C_{5i}\,\mathrm{CPI_{t-i}} \\
&\quad + \textstyle\sum_{i=1}^{n} D_{5i}\,\mathrm{HPI_{t-i}} + \sum_{i=1}^{n} E_{5i}\,\mathrm{LTV_{t-i}} + \sum_{i=1}^{n} F_{5i}\,\mathrm{DUM_{t-i}} + \epsilon_{5t} \qquad (8)\\
\mathrm{DUM_t} &= a_6 + \textstyle\sum_{i=1}^{n} A_{6i}\,\mathrm{NPL_{t-i}} + \sum_{i=1}^{n} B_{6i}\,\mathrm{GDP_{t-i}} + \sum_{i=1}^{n} C_{6i}\,\mathrm{CPI_{t-i}} \\
&\quad + \textstyle\sum_{i=1}^{n} D_{6i}\,\mathrm{HPI_{t-i}} + \sum_{i=1}^{n} E_{6i}\,\mathrm{LTV_{t-i}} + \sum_{i=1}^{n} F_{6i}\,\mathrm{DUM_{t-i}} + \epsilon_{6t} \qquad (9)
\end{aligned}$$

Where NPL_t is the logarithm of the non-performing loan change at period t
GDP_t is the logarithm of the gross domestic product change at period t
CPI_t is the change of consumer price index at period t
HPI_t is the change of housing price index at period t
LTV_t is loan amount to collateralized asset value at period t
DUM_t is the dummy variable representing crisis issues at period t

Impulse Response Function derived from Vector Moving Average (VMA) is used to analyze the effect of intermediate changes of a certain variable on changes of other variables in VAR model and analyze how long the short run adjustment would be processed until it reaches the equilibrium. VMA equation is shown in equation (10) (Enders, 2004).

$$\mathrm{Y_t} = \mu + \sum_{i=0}^{\infty} \phi_i\, \varepsilon_{t-1} \qquad (10)$$

where ϕ_i is the Impulse Response Function

Both value-at-risk (VaR) and conditional value-at-risk (CVaR) methods are used to estimate loan-loss provision, credit risk capital requirement, and capital buffer that bank needs to cover tail credit losses under the distressed scenario. Monte Carlo simulation is also employed to simulate the probability of default (PD) for a case of base line scenario and stress scenario. PD shows in equation (11) based on Fungacova and Jakubik (2012) studying the Russian credit crisis.

$$\mathrm{PD_t} = \frac{\mathrm{NPL_{t+1}} - \mathrm{NPL_t} - (\mathrm{r} \times \mathrm{NPL_t})}{(\mathrm{Loan_t} - \mathrm{NPL_t})} \qquad (11)$$

To come up with the amount of expected loss (EL) and unexpected loss (UL) this study computes EL and UL from the formula stated by the bank of Thailand as shown in equation (12).[1]

[1] Minimum LGD announced by the FPG. 2555/16the credit and operational risks for banks using the IRB approach FIRB collateral Residential Real Estate (RRE) equals 35percent.

$$EL_t = PD_t{}^2 \times \overline{LGD} \times EAD_t \quad (12)$$

VaR at the confidence level 99.9 percent is used to calculate unexpected loss for credit risk capital charge under an assumption of normal economic situation. VaR, expected loss, and unexpected loss as credit risk capital requirement, are calculated for period t as shown in equation (13).

$$Unexpected\ Loss\ (Capital\ Requirement) = VaR_t(0.999) - EL_t \quad (13)$$

Moreover, Adrian and Brunnermeier (2009) suggested a conditional VaR (CVaR), unconditional standard VaR, that bank has to set capital aside in case of credit stress especially under a systemic risk environment. Therefore, CVaR is more appropriate as a measure of risk spillover to determine capital margin (capital buffer) at confidence level of 99.9 percent which is shown in equation (14).

$$Capital\ Buffer = CVaR_t(0.999) - VaR_t(0.999) \quad (14)$$

RESULTS

Table 1 reveals the result of unit root tested by Augmented Dickey–Fuller Test showing that these variables; i.e. the NPLs, the gross domestic product (GDP), consumer price index (CPI) and the housing price index (HPI), have Augmented Dickey–Fuller Test statistic less than Mackinnon critical value at 5% significant level. That means all three models: 1) model without intercept and trend, 2) model with intercept, and 3) model with intercept and trend have stationary at first difference.

Table 1: Unit Root Test using Augmented Dickey–Fuller (ADF) Test

Variable	Models	ADF-Statistics	P-Value	Critical Value at 5%
1st Difference of NPL	With trend and intercept	-4.674360	0.0041	-3.568379
	With intercept	-3.625354	0.0111	-2.963972
	None	-3.566430	0.0009	-1.952473
1st Difference of GDP	With trend and intercept	-7.098509	0.0000	-3.562882
	With intercept	-7.243529	0.0000	-2.960411
	None	-6.616333	0.0000	-1.952066
1st Difference of CPI	With trend and intercept	-5.419517	0.0007	-3.568379
	With intercept	-5.521512	0.0001	-2.963972
	None	-3.705859	0.0006	-1.952473
1st Difference of HPI	With trend and intercept	-4.134298	0.0145	-3.568379
	With intercept	-4.135791	0.0032	-2.963972
	None	-4.004573	0.0002	-1.952473

[2] Bank of Thailand requires commercial banks to estimate the PD or the probability that the debtor defaults on the 1-year period and for small debtors PD must not be lower than 0.03 percent.

Johansen Cointegration test is conducted to trace whether there is a long-run relationship across multiple time series among interested variables (Johansen and Juselius, 1990). Optimal lag length(s) is analyzed to minimize the sum or squared residuals for the VAR. The result in Table 2 shows the maximum number of VAR lags is 4 determined by the lowest AIC, SC/SBC, and HQIC.

Table 2: Appropriate Lag for VAR Model

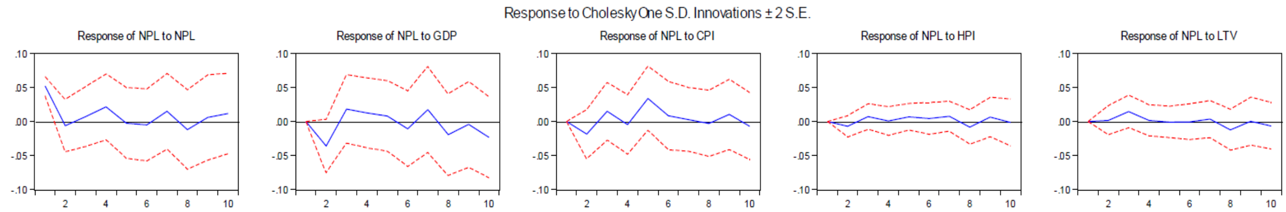
Lag length	AIC	SC or SBC	HQIC
0	1.501542	1.739436	1.574269
1	-0.559768	0.867594	-0.123410
2	-1.077006	1.539825	-0.277014
3	-2.751729	1.054569	-1.588106
4	-5.753033*	-0.757267*	-4.225778*

Note: AIC is Akaike Information Criteria
SC is Schwartz Bayesian Criteria
HQIC is Hannan-Quinn Information Criteria

Table 3 shows the VAR model specification. The result shows that VAR model is appropriate and the adjusted R^2 at 94%

The Impulse Response Function (IRF) provides the reaction information on how variables in the systems response over time to various shocks. The reaction result of each variable is shown in Figure 2. The picture indicates that if the GDP and CPI are shocked, there will affect the NPL in a downward direction during the first two quarters. Then, NPL will adjust to the long-run equilibrium in the 3rd quarter. However, in a short run process adjustments from the HPI and LTV changes have little effect on NPL.

Figure 2: Reaction of Macroeconomics Variable to NPL



The second part of this study is to estimate the banks' reserve for credit risk provision and credit risk capital charge to cover unexpected credit loss. In addition, this part also calculates capital buffer that banks need to hold against tail credit risk under the distressed scenarios. The probability of default will be calculated according to equation (11). Distribution testing of the default probability in normal circumstances (base line which assuming a 4 percent GDP increase from the previous year based on the Office of the National Economic and Social Development Board (NESDB)) and the default probability in the stress scenario (assuming a 1 percent GDP decrease for 4 consecutive quarters) is done by using Kolmogorov-Smirnov test. The result reveals that probability of credit default (PD) of base line and stress situations have beta distribution with p-value greater than alpha at 5 percent. The parameter estimation for beta distribution using maximum likelihood approach is shown in Table 4.

Table 3: Model Specification by using VAR Model

Variables	Lag length	Coefficient	t-statistic
NPL	(-1)	-1.021242*	-2.92875
	(-2)	0.229255	1.08165
	(-3)	2.549690*	3.93325
	(-4)	-0.503233***	-1.82252
GDP	(-1)	-1.140247*	-3.44108
	(-2)	-1.792010**	-2.71294
	(-3)	1.958208*	3.42925
	(-4)	-0.126946	-0.39826
CPI	(-1)	-0.044378*	-2.91766
	(-2)	0.075320*	4.43132
	(-3)	0.003946	0.30659
	(-4)	0.069959*	5.26532
HPI	(-1)	0.003966	1.51822
	(-2)	-0.003818**	-2.18999
	(-3)	-0.007119*	-2.93799
	(-4)	0.004888***	2.02127
LTV	(-1)	1.210901**	2.14155
	(-2)	1.929759**	2.43929
	(-3)	-5.374473*	-3.42661
	(-4)	3.015944*	3.14275
DUMMY	(-1)	0.090886**	2.25637
	(-2)	0.272619*	4.30710
	(-3)	0.189630*	3.36613
	(-4)	-0.008958	-0.21264

Constant	-0.700278	-3.06712
Adjusted R^2	0.946521	
F-statistic	29.02304	
Sample (adjusted):	33	

*significant level at 1% **significant level at 5% *** significant level at 10%

Table 4: Beta Parameters using Maximum Likelihood Method

Parameters	Base Line		Stress	
	Q1/2014	Q2/2014	Q1/2014	Q2/2014
A	0.78853	0.85891	0.77727	0.81481
B	1.92080	2.01260	1.43970	1.51360
δ (Lower Bound)	0.00218	0.00110	0.00227	0.00227
ϑ (Upper Bound)	0.05135	0.05135	0.04247	0.04247

The simulation result of default probability with a beta distribution under the normal case (base line) of the first quarter, 2014shows that the average value of 100,000 simulated PD is 0.01524with and a standard deviation of .0.00965 On the other hand, the result of 100,000 simulated default probability with a beta distribution under stress of the first quarter, 2014 shows that the average value is 0.01544 and a standard deviation is 0.00962.

While treating other macroeconomic variables constant same as Q4-2013, the results of NPL in Q1-2014 and Q2-2014 under a base line and a stress environment are shown in Table 5. The impact of a quarterly 4 percent increase in GDP from Q4-2013 has an impact on NPL and causes NPL ratio growing to 4.11 percent in Q1-2014 and 3.97 percent in Q2-2014. However, under the distressed scenario a quarterly 1 percent decrease in GDP from Q4-2013 has a higher impact on housing credit loss. NPL rises to 4.14 percent and 4.33 percent in Q1-2014 and Q2-2014, respectively under a stress situation.

Table 5: Results of NPL under Base Line and Stress

Macroeconomic Factor	Q4-2013	Q1-2014		Q2-2014	
		Base Line	Stress	Base Line	Stress
NPL ratio	3.6824	4.1100	4.1480	3.9703	4.3342
GDP (%qoq)	1.0000	4.0000	-1.0000	4.0000	-1.0000
CPI (%change)	0.5100	0.5100	0.5100	0.5100	0.5100
HPI (%change)	0.1276	0.1276	0.1276	0.1276	0.1276
LTV (%)	95.0000	95.0000	95.0000	95.0000	95.0000

The result in Table 6 reveals that under normal economy following the assumption of no stress situation the ratio of reserves or provision of total housing loan exposure to total debt (%EL) is 0.4759 in Q1-2014 and it is equal to 0.4720 in the next quarter. The provision value for credit risk is equal to 7,173 million baht in Q1-2014 and 7,288.39 million baht in the next quarter. Under the stress scenario it is however found that percent of expected credit loss is increasing to 0.4840 percent and 0.4845 percent in Q1-2014 and Q2-2014, respectively. The amount of loan provision is equal to 7,294.60 million baht in Q1-2014 and 7,494.70 million baht in Q2-2014.

Table 6: Provision under Base Line and Stress

Provision	Q1-2014		Q2-2014	
	Base Line	**Stress**	**Base Line**	**Stress**
%	0.4759	0.4840	0.4720	0.4854
Million Baht	7,173.00	7,294.60	7,288.39	7,494.70

Housing loan credit risk capital charge and capital buffer are calculated using VaR and CVaR. Under a normal environment VaR is used to estimate credit risk capital requirement as a cushion for unexpected credit loss. Reserving only provision mentioned above is not enough to ensure bank financial solvency. Therefore, bank is required to hold credit risk capital in addition to expected credit loss provision. Credit risk capital requirement would be 5,554.14 million baht in Q1-2014 and 5,791.66 million in Q2-2014. The credit risk capital requirement as mentioned and details of unexpected credit loss under a base line (normal economic situation) using VaR measurement are shown in Table 7.

Table 7: Unexpected Loss using Value-at-Risk and Credit Risk Capital Requirement under a Base Line

Unexpected Loss and Capital Requirement		Q1-2014	Q2-2014
		Base Line	**Base Line**
Unexpected Loss	**$VaR_{0.999}$ (%)**	1.3192	1.3204
	%	0.8472	0.8445
	Million Baht	13,080.04	12,727.13
Credit Risk Capital Requirement	**Million Baht**	5,791.66	5,554.14

CVaR calculation shows that under a stress scenario commercial banks are required to hold additional capital buffer to create more resilience against structural or systemic risk. The capital buffer is 0.0044 percent of total outstanding or 65.94 million baht for Q1-2014. The capital buffer in Q2-2014 is increasing to 0.0064 percent of total outstanding or 99.55 million baht. The details discussed above are shown in Table 8.

Table 8: Conditional Value-at-Risk (CVaR) and Capital Buffer

CVaR and Capital Buffer		Q1-2014	Q2-2014
		Stress	**Stress**
$CVaR_{0.999}$	**$CVaR_{0.999}$ (%)**	3.7881	3.7805
	%	0.0044	0.0064
Capital Buffer	**Million Baht**	65.9398	99.5540

CONCLUSIONS

The study found that the imposition of loan-to-collateral ratio (LTV) as a macroprudential instrument is associated with changes in non-performing housing loans. The adjustment of LTV to reduce NPL would take at least 4 quarters.

In addition, the result of this paper found that macroeconomic factors--GDP, CPI, and HPI--also significantly affect non-performing housing loans. GDP changes have a negative impact on NPL. Therefore, regulator should use both retrospective and prospective macroprudential policy to control financial institutions. This is because the policy will not immediately affect NPL but it would have a lag time of four quarters to be effective.

This study also found that the Bank of Thailand has overestimated the loan provision requirement of 1.00 percent of total outstanding debt. This is because the evidence shows that the loan provisions as shown in Table 6 are approximately only 0.48 percent of total debt in both scenarios of base line and stress.

In addition, the study reveals that value-at-risk (VaR) measuring credit loss under a baseline economic scenario is not the proper approach to determine the regulatory credit risk capital under a stress. Regulator enforces only credit risk capital requirement would lead bank a capital deficiency under a severe adverse economic scenario. Under a stress environment regulator needs commercial bank to hold additional capital buffer as a cushion to shield against systemic risk. Therefore, conditional value-at-risk (CVaR) may represent a better choice for estimating capital buffer as safeguard for banks taking account of the macro-financial environment. That is shown by the evidence of the highest loss amount under adverse economic shock normally outweighing the unexpected credit loss using VaR measurement.

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