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CAN BASEL III LIQUIDITY RISK MEASURES EXPLAIN TAIWAN BANK FAILURES

Abstract:

In December 2010, the BCBS (2010a) strengthened its liquidity framework by proposing two quantitative indicators for liquidity risk in Basel III: the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR). Whether the new liquidity risk indicators are effective to measure the liquidity risk of bank thereby reducing bank failures is an issue of concern. Thus, this study uses a quarterly data of Taiwan banks from 2006 to 2013 and uses the panel multiple regression model to investigate the effectiveness of LCR and NSFR in Taiwan banks. We also study the effectiveness of spread and several liquidity risk indictors used in Taiwan based on Principles for Sound Liquidity Risk Management and Supervision (PSLRMS). Moreover, we test the liquidity risk majored from systematic or non-systematic risk, and consider the size effect and time effect to compare the result. The result shows that all liquidity risk indicators can explain empirical default point (EDD) significantly, for big banks, LCR is more important than NSFR, but for small banks, NSFR is more important. In crisis period, spread and LCR are significant in big banks, but no indicators are significant in small banks. After crisis, both big and small banks are affected by spread, and NSFR and LCR is significant in small bank and in big bank, respectively.

Keywords:

Subprime mortgage crisis, Basel III, The Liquidity Coverage Ratio, The Net Stable Funding Ratio, Size effect

1. Introduction

U.S subprime mortgage crisis cause the deflation of money market, and many banks faced a crisis due to failure of liquidity management even if their capital is sufficient. The length and severity of the liquidity disruption during the financial crisis of 2007-2009 has prompted regulators to emphasize the importance of sound liquidity risk management. Thus, Basel Committee on Banking Supervision (BCBS) released Principles for Sound Liquidity Risk Management and Supervision (PSLRMS) in 2008. In December 2010, the BCBS (2010a) strengthened its liquidity framework by proposing two quantitative indicators for liquidity risk in Basel III. The liquidity coverage ratio (LCR) standard requires that banks have sufficient high-quality liquid assets to survive a significant stress scenario over one month, and the net stable funding ratio (NSFR) standard induces banks to fund their activities with more stable sources of funding.

Do the new liquidity risk indicators effective to forecast the liquidity risk of bank thereby reducing bank failures? To the best of our knowledge, few studies have examined the new liquidity risk indicators proposed in Basel III. In recent years, increasing related researches concerned with the liquidity risk measurement but they have not a consistent conclusion to measure liquidity risk. Therefore, it is our principal motivation to investigate the effectiveness of the new liquidity risk indicators, which can be regard as the non-systematic liquidity risk. Apart from this, we also probe the effectiveness of spread, which is conceptually similar to TED spread as a substitute value of Taiwan's market liquidity risk and systemic liquidity risk, and several liquidity risk indictors used in Taiwan based on PSLRMS. The liquidity risk indictors proposed in Basel III are called "new liquidity risk indictors", and liquidity risk indictors used in Taiwan based on PSLRMS are called "traditional liquidity risk indictors in this paper.

The purpose and contributions of this paper is to develop three hypotheses to investigate whether LCR and NSFR (non-systemic liquidity risk) based on BCBS liquidity specification and Spread (systemic liquidity risk) can effectively predict defaults for banks in Taiwan and to investigate the effectiveness of liquidity risk indicators under the different size and time period. We examine these questions by using the panel multiple regression models. The dependent variable is the distance to default (DD) or the probability of default (DP), one of the empirical default point (EDD), theoretical default point (TDD), empirical probability of default (EPD) or theoretical probability of default (TPD). We employ the KMV model to estimate the distance to default (DD) as a substitute value of bank's liquidity risk. The independent variables include the spread, new liquidity risk indictors and traditional risk indicators. The new liquidity risk indictors contain the liquidity coverage ratio (LCR) and net stable funding ratio (NSFR), and the traditional risk indicators include the current ratio (CR), the gap of MCO ratio (GMCOR), the bad loan ratio (BLR), the capital adequacy ratio (CAR), the loss provision coverage (LPC), the loan to deposit ratio (LDR) and the liquidity reserves ratio (LRR). For the purpose of approximate estimation, we calculate these indictors that are conceptually similar to their framework using the existing data of Taiwan banks. This task faces several obstacles, such as the ambiguities in certain Basel III guidelines, gaps between the existing data and the information required for calculating the new liquidity risk ratios. Therefore, we have to use our best judgments when interpreting certain guidelines, and to rely on interpolation and extrapolation techniques to fill data gaps.

The empirical result shows that all liquidity risk indicators can explain empirical default point (EDD) significantly, for big banks, LCR is more important than NSFR, but for small banks, NSFR is more important. In crisis period, Spread and LCR are significant in big banks, but no indicators are significant in small banks. After crisis, both big and small banks are affected by Spread, while NSFR and LCR is significant in small bank and in big bank, respectively. We also find that, the liquidity risk source is major from non-systemic on the whole banks. Under the size effect, the big scale banks are affected by both non-systemic and systemic risk, whereas the small scale banks are affected by non-systemic. Under the time effect, the whole banks are affected by non-systemic in crisis period, whereas the whole banks are affected by both non-systemic and systemic risk after the crisis. Therefore, our three hypotheses all hold. We also find that LCR of the big scale banks is the most important indictor to hold the whole financial system in the crisis period. Thus, this finding lead us to believe that the impact of non-systemic liquidity risk is large than systemic liquidity risk. In other words, if all banks have very stable constitution and have outstanding liquidity risk indicators, non-systemic liquidity risk will dominate systemic liquidity risk in the crisis period and then stabilize the whole market.

The remainder of this paper is organized as follows. Section 2 reviews the literature. Section 3 describes the data source, measurements and model. Section 4 is empirical result. Section 5 is conclusions and recommendations.

2. Literature Review

Since the outbreak of U.S subprime mortgage crisis in 2007, the global credit markets and financial system liquidity become worse. This situation caused a serious impact on financial system and global economic growth. Thus, in order to reduce the impact of liquidity risk, the supervisory authority start looking for the measurement of liquidity risk, and want to know their effectiveness. In this paper, we choose two new liquidity risk indicators proposed in Basel III (new liquidity risk indicators) and several indicators based on PSLRMS have used in Taiwan (traditional liquidity risk indictors) to investigate their effectiveness. Below we briefly describe the new liquidity risk indictors and traditional liquidity risk indictors.

2.1 Traditional liquidity risk indictors

The traditional liquidity risk indictors in this paper means the liquidity risk indictors used in Taiwan based on PSLRMS, including 14 indictors. Finally, we use 7 indictors in this paper excluding the indictors that unable to obtain in the public information. These 7 indictors contains the gap of maximum cumulative outflow ratio (GMCOR), bad loan ratio (BLR), current ratio (CR), capital adequacy ratio (CAR), loss provision coverage ratio (LPC), loan to deposit ratio (LDR) and the liquid reserves ratio (LRR), respectively. Below we briefly describe these ratios.

2.1.1 Gap of Maximum Cumulative Outflow Ratio (GMCOR)

The gap of maximum cumulative outflow ratio is a coincident index that to measure the gap of one month maximum cumulative outflow (MCO) have what proportion of accounts for total outflow, in which MCO is a static funding gap that edit based on maturities of assets and liabilities. When the GMCOR higher, the potential one month funding gap is bigger. That means that we should more concern about the short term liquidity. Here is the calculation:

$$GMCOR = \frac{\text{one month funds maximum Cumulative Outflow}}{one\ month\ total\ funds\ Outflow} \quad (1)$$

2.1.2 Bad Loan Ratio (BLR)

The bad loan ratio is a leading index that to measure the non-performing loan assets of total loan assets. When the BLR rises, the bank will faced with more serious liquidity issues. Here is the calculation:

$$BLR = \frac{\text{Non Performing Loan assets}}{Total\ Loan\ assets} \quad (2)$$

Because that the BLR is unable to obtain in public information, BLR will be replaced with Non-performing Ratio (NPL) in this paper.

2.1.3 Current Ratio (CR)

The current ratio is a liquidity and efficiency ratio that measures a firm's ability to pay off its short-term liabilities with its current assets. The current ratio is a coincident index and is an important measure of liquidity because short-term liabilities are due within the next year. If banks with larger amounts of current assets will more easily be able to pay off current liabilities when they become due without having to sell off long-term, revenue generating assets. A higher current ratio is always more favorable than a lower current ratio because it shows the bank can more easily make current debt payments. Thus, the bank will have higher liquidity (Demiroglu and James,2000; Samad and Hassan,2000). Here is the calculation:

$$CR = \frac{\text{Current Assets}}{Current\ Liabilities} \quad (3)$$

2.1.4 Capital Adequacy Ratio (CAR)

Capital adequacy ratio (CAR) is a specialized ratio used by banks to determine the adequacy of their capital keeping in view their risk exposures. Banking regulators require a minimum capital adequacy ratio so as to provide the banks with a cushion to absorb losses before they become insolvent. This improves stability in financial markets and protects deposit-holders. Basel Committee on Banking Supervision of the Bank of International Settlements develops rules related to capital adequacy which member countries are expected to follow. Here is the calculation:

$$CAR = \frac{Tier\ 1\ Capital + Tier\ 2\ Capital}{Risk\ Weighted\ Asset} \quad (4)$$

Where

Tier 1 Capital = Common Equity Tier 1 + Additional Tier 1

Total Capital = Tier 1 Capital + Tier 2 Capital

Risk-weighted exposures include weighted sum of the bank credit exposures (including those appearing on the bank's balance sheet and those not appearing). The weights are determined in accordance with the Basel Committee guidance for assets of each credit rating slab. The pronouncement requires banks to maintain the minimum ratios as 8% of 1 January 2013. A higher capital adequacy ratio always has lower likelihood of liquidity crisis.

2.1.5 Loss Provision Coverage Ratio (LPC)

The loss provision coverage ratio is a leading index that measures the loss reserve of non-performing assets. The bank will have the stronger ability to withstand losses when the bank’s LPC is higher. Thus, the likelihood of a liquidity crisis is lower. Here is the calculation:

$$LPC = \frac{\text{Loss Reserve}}{Non\ Performing\ Loan\ Assets} \quad (5)$$

Because that the LPC is unable to obtain in public information, LPC will be replaced with Allowance for uncollectible account Coverage Ratio (ACR) in this paper.

2.1.6 Loan to Deposit Ratio (LDR)

The loan to deposit ratio is a coincident index that used to calculate a lending institution's ability to cover withdrawals made by its customers. A lending institution that accepts deposits must have a certain measure of liquidity to maintain its normal daily operations. Loans given to its customers are mostly not considered liquid meaning that they are investments over a longer period of time. Although a bank will keep a certain level of mandatory reserves, they may also choose to keep a percentage of their non-lending investing in short term securities to ensure that any monies needed can be accessed in the short term. Hence, the bank needs to pay attention to the liquidity issues when the LDR is rising (Honohan and Klingebiel, 2003; Samad and Hassan, 2000). Here is the calculation:

$$LDR = \frac{\text{Loan}}{Deposit} \tag{6}$$

2.1.7 Liquid Reserves Ratio (LRR).

The liquidity reserves ratio is a coincident index that measures the bank's low profitability and highly liquid assets of deposit. A higher LRR means that the bank's liquidity is better. Here is the calculation:

$$LRR = \frac{Real\ Allocate\ Liquid\ Reserves}{Required\ Allocate\ Liquid\ Reserves\ Basis} \tag{7}$$

2.2 New liquidity risk indictors

The new liquidity risk indictors in this paper include two liquidity risk indictors proposed in Basel III. One is the liquidity coverage ratio (LCR), another is the net stable funding ratio (NSFR). Below we briefly describe these ratios.

2.2.1 The liquidity coverage ratio (LCR)

The liquidity coverage ratio is an important part of the Basel Accords that designed to ensure that financial institutions have the necessary assets on hand to ride out short-term liquidity disruptions. Banks are required to hold an amount of highly-liquid assets that can be converted into cash to meet its liquidity needs for 30 days under a significantly severe liquidity stress scenario. Based on this standard, the LCR, which is defined as the stock of high-quality liquid assets divided by the total net cash outflows over the next 30 calendar days, is required to be above 100%. Here is the calculation:

$$LCR = \frac{\text{Stock of High Quality Liquidity Asset}}{Total\ net\ cash\ outflows\ over\ the\ next\ 30\ calendar\ days} \tag{8}$$

The calculation of LCR depends on several assumptions and how to calculate the stock of high-quality liquid assets and the total net cash outflows. These assumptions and the measurement will be described in section 3

2.2.2 The net stable funding ratio (NSFR)

The net stable funding ratio measures the amount of longer-term, stable sources of funding employed by an institution relative to the liquidity profiles of the assets funded and the potential for contingent calls on funding liquidity arising from off-balance sheet commitments and obligations. The standard requires a minimum amount of funding that is expected to be stable over a one year time horizon based on liquidity risk factors assigned to assets and off-balance sheet liquidity exposures. The NSFR is intended to promote longer-term structural funding of banks' balance sheets, off-balance sheet exposures and capital markets activities. In the other words, the NSFR standard was developed to promote medium and long-term funding stability. Based on this standard, the NSFR, which is defined as follow, is required to be greater than 100%. Here is the calculation:

$$NSFR = \frac{\text{Available amount of stable funding}}{Required\ amount\ of\ stable\ funding} \quad (9)$$

The calculation of the NSFR depends on assumptions and how to calculate the available amount of stable funding and the required amount of stable funding. These assumptions and the measurement will be described in section 3.

2.3 The Hypothesis

In recent theoretical research, He and Xiong (2012) considered that the liquidity in bond market can be used as a common economic factors as a predictor of company default. Axharya, Gale, and Yorulmazer et al (2011), emphasized that the systemic nature in rollover risk will cause whole market illiquidity. In empirical research, Berger and Bouwman (2009) pointed out the crisis of bank is mainly due to the heterogeneity liquidity in U.S. Wu and Hong (2012) investigated linkages between the bank failures and liquidity risk in U.S. The result showed that the market liquidity risk (TED Spread) has significant predictive power for U.S banks failures, but the two new liquidity risk indictors proposed in Basel III (LCR and NSFR) are not. Wan-Hsuan Lee (2014) further wanted to know whether they have the same outcomes in Taiwan banks. They use the spread between three months Taipei Interbank Offered Rate (TAIBOR) and Taiwan three month deposit rate as a substitute value of market liquidity risk. Moreover, they consider the size effect to employ regression analysis. The result showed that, no matter in whole banks, big scale or small scale, spread is significant, while LCR is showing significant in big scale, NSFR is showing significant in whole banks and small scale. This result is different from Wu and Hong (2012). As regards the traditional indicators, no matter in whole banks, big scale or small scale are not significant in Taiwan. Thus, we would like to investigate the empirical analysis when using the traditional liquidity risk based on PSLRMS as control variables in Taiwan banks. Moreover, we also would like test the liquidity risk major from system or non-system risk in Taiwan banks. We also want to investigate the effects of liquidity risk on bank failure during the subprime periods and after subprime crisis in Taiwan banks.

Therefore, we develop several hypotheses to investigate in this paper, as follows:

H_1: The new liquidity risk indictors and spread are useful and effective in Taiwan banks.

H_2: Under the size effect, different scale has different sources of liquidity risk in Taiwan banks.

H_3: Under the time effect, different period have different sources of liquidity risk in Taiwan banks.

3. Data and Model

The sample period spans the period from 2006 to 2013.This study uses a quarterly data from the cumulative quarterly statements of Taiwan banks obtained from the Taiwan Economic Journal (TEJ), the three month Taipei Interbank Offered Rate (TAIBOR) obtained from The Banks Association of Taiwan (BAOT) and Taiwan three month deposit rate obtained from Central Bank of Taiwan (CBOT). Subjects were composed of 23 publicly held banks in the Taiwan OTC Exchange excluding the bank when most of the data are missing. Table 1 shows the 23 bank’s names of our sample. These subjects also have gaps between the existing data. Therefore, this study has to use linear interpolation, nonlinear interpolation and extrapolation techniques to fill data gaps. Hence, the final quarterly data set includes 6,624 observations.

3.1 Variables

In this paper, the dependent variable is empirical default point (EDD), theoretical default point (TDD), empirical probability of default (EPD) or theoretical probability of default (TPD), and the independent variable are Spread, LCR, NSFR, GMCOR, BLR, CR, CAR, LPC, LDR and LRR. This paper calculates two liquidity risk ratios that are conceptually similar to the LCR and NSFR of the Basel III liquidity risk framework and GMCOR that is the liquidity risk ratio used in Taiwan based on Basel’s Principles for Sound Liquidity Risk Management and Supervision (PSLRMS). This task faces several obstacles, such us the ambiguities in certain Basel III guidelines and the information required for calculating the liquidity risk ratios. Therefore, we have to use our best judgments when interpreting certain guidelines. Limited to the information obtains, we use the original edition to calculate NSFR even if the NSFR of Basel III have the newest edition. Table 2 and Table 3 reports the formulas, data source and measurement of the variables. Table 4 summarizes the components of HQLA and total net cash outflows of LCR and reports how to calculate it respectively. Table 5 and Table 6 summarizes the components of ASF and RSF of NSFR.

Table 1

Size classification of sample bank

Sample bank names	
Chang Hwa Bank	Far Eastern International Bank
Taichung Bank	JihSun International Commercial Bank
China Development Industrial Bank	Union Bank of Taiwan
Hua Nan Bank	Ta Chong Bank
Bank SinoPac	CTBC Bank
King’s Town Bank	Shin Kong Bank
Taiwan Business Bank	E.Sun Bank
TaipeiFubon Bank	KGI Bank (former Cosmos Bank)
Cathay United Bank	Mega International Commercial Bank
Taishin International Bank	Entie Commercial Bank
Bank of Kaohsiung	Yuanta Commercial Bank
	First Bank

This table presents 23 bank’s names of our sample.

Table 2

Dependent Variable Descriptive

Dependent variable			
	Formula	Data Source	Measurement
EDD	$\frac{E(V_A) - DPT}{E(V_A) \times \sigma_A}$	TEJ	Descriptive in Model
TDD	$\frac{\ln \frac{V_A}{DPT_t} + \left(\mu - \frac{\sigma_A^2}{2}\right)t}{\sigma_A \sqrt{t}}$	TEJ	Descriptive in Model
EPD	$N(-\frac{E(V_A) - DPT}{E(V_A) \times \sigma_A})$	TEJ	Descriptive in Model
TPD	$N(-\frac{\ln \frac{V_A}{DPT_t} + \left(\mu - \frac{\sigma_A^2}{2}\right)t}{\sigma_A \sqrt{t}})$	TEJ	Descriptive in Model

This table presents dependent variable's formula, data source and measures.

Table 3

Independent Variable Descriptive

Independent variable			
	Formula	Data Source	Measurement
Spread	three month TAIBOR - Taiwan three month deposit rate	BAOT CBOT	Apply the Formula
LCR	$\frac{\text{Stock of HQLA}}{\text{Total net cash outflows over the next 30 calendar days}}$ Where HOLA = High Quality Liquidity Asset	TEJ	Descriptive in Table 4
NSFR	$\frac{\text{Available amount of stable funding}}{\text{Required amount of stable funding}}$	TEJ	Descriptive in Table 5、6
GMCOR	$\frac{\text{one month funds maximum Cumulative Outflow}}{\text{one month total funds Outflow}}$	TEJ	Apply the Formula
BLR	Replace with NPL , $\frac{\text{Non Performing Loans}}{\text{Total Loans}}$ Where NPL =Non Performing Loans Ratio	TEJ	Ratio in statements from TEJ
CR	$\frac{\text{Current Assets}}{\text{Current Liabilities}}$	TEJ	Ratio in statements from TEJ

CAR	$\frac{Tier\ 1\ Capital + Tier\ 2\ Capital + Tier\ 3\ Capital}{Risk\ Weighted\ Asset + 12.5 * (MRC + ORC)}$ Where MRC = market risk charge , ORC = operational risk charge	TEJ	Ratio in statements from TEJ
LPC	Replace with ACR , $\frac{\text{allowance for uncollectible account}}{Non\ Performing\ Loans}$ Where ACR = allowance for uncollectible account coverage ratio	TEJ	Ratio in statements from TEJ
LDR	$\frac{\text{Loan}}{Deposit}$	TEJ	Ratio in statements from TEJ
LRR	$\frac{Real\ Allocate\ Liquid\ Reserves}{Required\ Allocate\ Liquid\ Reserves\ Basis}$	TEJ	Ratio in statements from TEJ

This table presents independent variable's formula, data source and measures. Where GMCOR, LCR, NSFR are calculated by myself. The others are obtained in statements from TEJ.

Table 4

The components of LCR

Stock of HQLA			
Item	Factor	Measurement	Weight
A. Level 1 assets			
1. Coins and bank notes 2. Qualifying securities from sovereigns, central banks, PSEs, and multilateral development banks 3. Qualifying central bank reserves 4. Domestic sovereign or central bank debt for non-0% risk-weighted sovereigns	100%	Level 1 assets in TEJ	100%
B. Level 2 assets (maximum of 40% of HQLA)			
Level 2A assets			
1. Sovereign, central bank, multilateral development banks, and PSE assets qualifying for 20% risk weighting 2. Qualifying corporate debt securities rated AA- or higher 3. Qualifying covered bonds rated AA- or	85%	Level 2 assets in TEJ	85%

higher			
Level 2B assets(maximum of 15% of HQLA)			
1. Qualifying RMBS	75%		
2. Qualifying corporate debt securities rated between A+ and BBB-	50%		
3. Qualifying common equity shares	50%		
Total value of stock of HQLA		Lv1 assets +(0.85*Lv2 assets)	
Cash Outflows			
A. Retail deposits	Annex	The main outflow of funds maturity in TEJ	100%
B. Unsecured wholesale funding			
C. Secured funding			
D. Additional requirements			
Any additional outflows			
Net derivative cash outflows			
Any other contractual cash outflows			
Cash Inflows			
Maturing secured lending transactions backed by the following collateral	Annex	The main Inflow of funds maturity in TEJ	100%
Margin lending backed by all other collateral			
All other assets			
Credit or liquidity facilities provided to the reporting bank			
Operational deposits held at other financial institutions			
Other inflows by counterparty			

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Net derivative cash inflows			
Other contractual cash inflows			
Total net cash outflows=The main outflow of funds maturity-Inflow of funds maturity			

This table presents the components of LCR and reports how I calculate it. In order to complete presents, some of detail items were be predigest in table.

Table 5

The components of available stable funding of NSFR

Available stable funding (ASF)			
Item	Factor	Measurement	Weight
1. The total amount of capital, including both Tier 1 and Tier 2 as defined in Basel III 2. The total amount of any preferred stock not included in Tier 2 that has an effective remaining maturity of one year or greater taking into account any explicit or embedded options that would reduce the expected maturity to less than one year 3. The total amount of secured and unsecured borrowings and liabilities (including term deposits) with effective remaining maturities of one year or greater excluding any instruments with explicit or embedded options that would reduce the expected maturity to less than one year. Such options include those exercisable at the investor's discretion within the one-year horizon	100%	Level 1 and 2 assets & Total liabilities of one year or more in TEJ	100%

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"Stable" non-maturity (demand) deposits and/or term deposits with residual maturities of less than one year provided by retail customers and small business customers.	85%	Deposits of less than one year in TEJ, but that can't distinguish stable or less stable from information. Therefore, use 70% to calculate.	70%
"Less stable" non-maturity (demand) deposits and/or term deposits with residual maturities of less than one year provided by retail and small business customers	70%		
Unsecured wholesale funding, non-maturity deposits and/or term deposits with a residual maturity of less than one year, provided by non-financial corporates, sovereigns, central banks, multilateral development banks and PSEs	50%	Unable to obtain in public information	0%
All other liabilities and equity categories not included in the above categories	0%		0%

This table presents the components of ASF of NSFR and reports how to calculate it.

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Table 6

The components of required stable funding of NSFR

Required stable funding (RSF)			
Item	Factor	Measurement	Weight
1. Cash immediately available to meet obligations, not currently encumbered as collateral and not held for planned use (as contingent collateral, salary payments, or for other reasons) 2. Unencumbered short-term unsecured instruments and transactions with outstanding maturities of less than one year 3. Unencumbered securities with stated remaining maturities of less than one year with no embedded options that would increase the expected maturity to more than one year 4. Unencumbered securities held where the institution has an offsetting reverse repurchase transaction when the security on each transaction has the same unique identifier (eg ISIN number or CUSIP) 5. Unencumbered loans to financial entities with effective remaining maturities of less than one year that are not renewable and for which the lender has an irrevocable right to call	0%	Cash、Interbank loan、short-term investment、RS、Available-for-Sale Financial Assets 、Held-to-Maturity Financial Assets in TEJ (less than one year)	0%
Unencumbered marketable securities with residual maturities of one year or greater representing claims on or claims guaranteed by sovereigns, central banks, BIS, IMF, EC, non-central government PSEs) or multilateral development banks that are assigned a 0% risk-weight under the Basel II standardized approach, provided that active repo or sale-markets exist for these securities	5%	Unable to obtain in public information	0%

1. Unencumbered corporate bonds or covered bonds rated AA- or higher with residual maturities of one year or greater satisfying all of the conditions for Level 2 assets in the original Dec. 2010 LCR framework [the Basel Committee has since revised the LCR framework] 2. Unencumbered marketable securities with residual maturities of one year or greater representing claims on or claims guaranteed by sovereigns, central banks, non-central government PSEs that are assigned a 20% risk-weight under the Basel II standardized approach, provided that they meet all of the conditions for Level 2 assets in the original Dec. 2010 LCR framework [the Basel Committee has since revised the LCR framework]	20%	Unable to obtain in public information	0%
1. Unencumbered gold 2. Unencumbered equity securities, not issued by financial institutions or their affiliates, listed on a recognized exchange and included in a large cap market index 3. Unencumbered corporate bonds and covered bonds that satisfy all of the following conditions (detail items in annex)	50%	Unable to obtain in public information	0%
Unencumbered loans to retail customers (i.e. natural persons) and small business customers (as defined in the original Dec. 2010 LCR framework) having a remaining maturity of less than one year (other than those that qualify for the 65% RSF above)	85%	Bills Purchased、Discounted and Loan in TEJ	85%
All other assets not included in the above categories	100%	Total assets minus asset items above	100%

This table presents the components of RSF of NSFR and reports how to calculate it. In order to complete presents, some of detail items were be predigest in table.

3.2 The KMV Model

KMV model is based on the structural approach put forward by Black, Scholes, (1973) and Merton (1974), and named with the first letters of three KMV's founder Kealhofer, McQuown and Vasicek (KMV). Based on the assumption of Merton's structural model, if the asset value of the bank is lower than the liabilities value when the liabilities expire, it is defined as the occurrence of default. Thus, based on the book value of liabilities, if we know the distribution of bank's asset value, we can further estimate the probability of default of the bank. However, the asset value is difficult to measure and unable to use the value of assets in the financial statements to calculate it, because that most of the historical cost of assets is a far cry from the current market value. The Distance to Default (DD) is a market-based measure of bank default risk. It is based on evaluation of assets in the stock markets, where participants are heterogeneous and diversified, and book values of short-term liabilities. It measures both solvency risk and liquidity risk. As the following steps, we can calculate the DD of KMV risk model:

First Step: Determine the value of assets (V) and their volatility (σ)

According to assumptions of KMV model, the capital structure is formed by equity, short-term liabilities that is equivalent to cash, and long-term liabilities that is considered sustainable pension and convertible preferred stock. In this assumption, according to the classic Black, Scholes, (1973) model, the option valuation model when sold had similarity with the default option; the current market value of the risk loans depends on 5 variables:

The value of defaults option of a risk loan is

$$V_E = \mathrm{f}(V_A, \mathrm{L}, \mathrm{r}, \sigma_A, T) \tag{10}$$

$$\mathrm{f}(V_A, \sigma_A) = V_E = V_A \times N(d_1) - Le^{-rT} N(d_2) \tag{11}$$

$$d_1 = \frac{\ln\left(\frac{V_A}{L}\right) + \left(r + \frac{\sigma_A^2}{2}\right)T}{\sigma\sqrt{T}} \tag{12}$$

$$d_2 = d_1 - \sigma\sqrt{T} \tag{13}$$

Where V_E is the market value of bank's equity (stock prices times the number of shares outstanding), V_A is the market value of the bank's assets. L is the bank's liability, r is the risk free rate. σ_A is the volatility of the bank's asset market value, T is the expiration date, and N(d) is the standard normal cumulative probability distribution function. There are two unknown variables, the V_A and σ_A, thus, this paper references iterative approach adopted by Harada et al (2010) to estimate the asset value and asset volatility of the bank. In order to estimate V_t, μ_A and σ_A, this paper uses the following steps.

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Step 1:

Set the initial estimate for $V_t^0, V_{t-1}^0, V_{t-2}^0, \dots, V_{t-n+1}^0$ (the previous quarter's data) based on V_E plus the book value of liabilities replace with the market price of bank's asset, then calculate σ_A^0, using equation (5). The superscript numbers indicates that number of estimate times of iterative approach.

$$\sigma_A = std(lnV_t - lnV_{t-1}) \times \sqrt{252} \tag{14}$$

Step2:

Next calculate $V_t^1, V_{t-1}^1, V_{t-2}^1, \dots, V_{t-n+1}^1$ with σ_A^0. Then calculate σ_A^1 , using equation (5) and calculate $V_t^2, V_{t-1}^2, V_{t-2}^2, \dots, V_{t-n+1}^2$ using σ_A^1.

Repeat these steps until $V_t^k, V_{t-1}^k, V_{t-2}^k, \dots, V_{t-n+1}^k$ and σ_A^k converge. Mean absolute percentage error (MAPE) less than 10^{-4} is the criteria that to determine whether convergence.

$$\frac{1}{n+1} \times \left(\left| \frac{\sigma_A^k - \sigma_A^{k-1}}{\sigma_A^k} \right| + \left| \frac{V_t^k - V_t^{k-1}}{V_t^k} \right| + \left| \frac{V_{t-1}^k - V_{t-1}^{k-1}}{V_t^k} \right| + \cdots + \left| \frac{V_{t-n+1}^k - V_{t-n+1}^{k-1}}{V_{t-n+1}^k} \right| \right) < 10^{-4} \tag{15}$$

Second Step: Calculate the "distance to default" (DD)

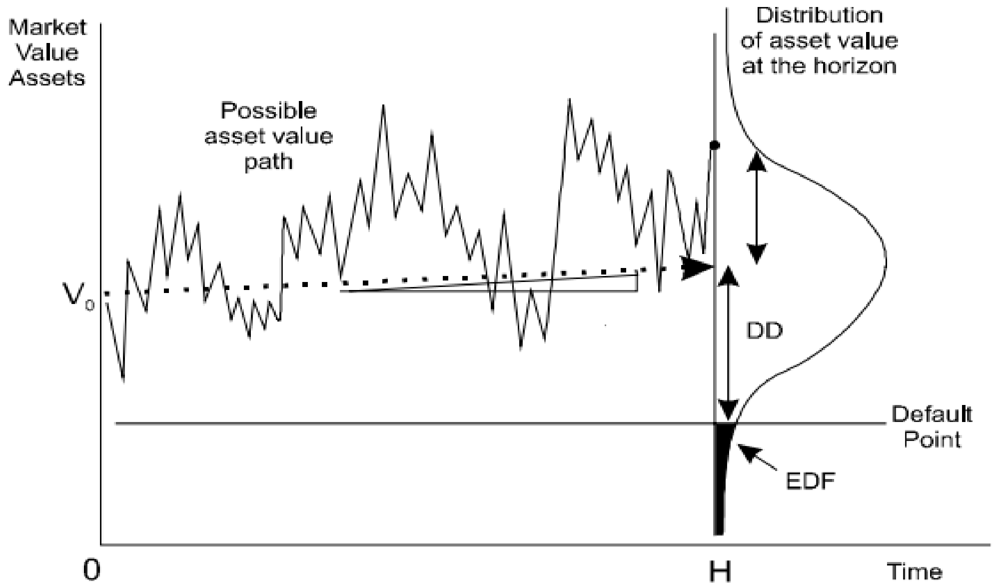
A key concept underlying the KMV approach is the recognition that a bank doesn't have to default the moment its asset value falls below the face value of liabilities-in fact default happens when value of the bank's assets falls somewhere between the value of the short term liabilities and the value of the total liabilities. In other words, it is possible to not have default even if the value of the assets has fallen to less than the total liabilities. Based on the empirical analysis of a large number of default facts, KMV found the critical point of the most frequently occurred defaults is at the point when the bank value is greater than or is equal to the sum of short-term liabilities and half the value of the long-term liabilities. Setting: SL for short-term liabilities; LL for long-term liabilities; DPT for default point threshold:

$$\mathrm{DPT} = \mathrm{SL} + \frac{1}{2}\mathrm{LL} \tag{16}$$

Next, to estimate the default distance (DD). DD is the relative distance the assets value falling down from the current level to the default point within the risk period, and the DD can be also expressed as the standard variance of the future assets expectation and the assets at the default point. It can be an indicator to measure the default risk and can compare the different banks. The larger number represents the value of assets farther away from the default point, therefore, the smaller default probability of bank, shown in Figure 1. According to Crosbie and Bohn (2003), the empirical default distance (Empirical DD) is expressed as follows:

$$\text{Empirical DD} = \frac{E(V_A) - DPT}{E(V_A) \times \sigma_A} \quad (17)$$

Figure 1 KMV model schematic diagram



In fact, the default distance can be derived to combine with risk of bankruptcy mode, assumed market value of asset lower than default point, therefore, the probability that the asset's market value become below the default point threshold is:

$$p_t = P_r[V_A^1 \leq DPT_t | V_A^0 = V_A] = P_r[lnDPT_t | V_A^0 = V_A].$$

Supposed the volatility of market value of bank's asset submit to lognormal distributions, then we can obtain

$$lnV_A^t = lnV_A + \left(\mu - \frac{\sigma_A^2}{2}\right)\mathrm{t} + \sigma_A\sqrt{t}\varepsilon$$

Where, $\varepsilon \sim \mathrm{N}(0,1)$

Thus, p_t is the bankruptcy probability of the bank, in other words, is the theoretical expected probability of default:

$$p_t = P_r[lnV_A + \left(\mu - \frac{\sigma_A^2}{2}\right)t + \sigma_A\sqrt{t}\varepsilon \leq lnD_t]$$

$$= P_r\left[-\frac{ln\frac{V_A}{DPT_t} + \left(\mu - \frac{\sigma_A^2}{2}\right)t}{\sigma_A\sqrt{t}} \geq \varepsilon\right]$$

$$= N\left[-\frac{ln\frac{V_A}{DPT_t} + \left(\mu - \frac{\sigma_A^2}{2}\right)t}{\sigma_A\sqrt{t}}\right] = \mathrm{N}(-\mathrm{DD})$$

Finally, the theoretical expected probability of default (Theoretical DD) is expressed as follows:

$$\text{Theoretical DD} = \frac{ln\frac{V_A}{DPT_t} + \left(\mu - \frac{\sigma_A^2}{2}\right)t}{\sigma_A\sqrt{t}} \qquad (18)$$

Thus, we calculate Empirical DD and Theoretical DD with V_A , σ_A , r , L and t to measure the bank's liquidity risk.

The fourth step: estimate the expected default probability (EDF) of the bank.

The expected default frequency (EDF) in the KMV model is determined by the mapping relation between the DD and the EDF. Therefore, to establish the mapping relation is the prerequisite to determine the expected default rate. However, due to the current deficient credit system in Taiwan, as there is a serious lack of the statistical data of the historical corporate default or bankruptcy, it is difficult to convert the DD into the actual default rate and to calculate the EDF. Nevertheless, the unique mapping relation between the DD and the EDF exists, which means the length of the DD can reflect the credibility of the bank to some extent. Therefore, in this paper, we use DD to replace the EDF.

3.3 Regression Model

By regression model, this study investigates the relationship between bank's liquidity risk and liquidity risk ratio, and the effectiveness of all liquidity risk ratio.

$$\mathrm{Y} = \alpha + \beta_1 * X_1 + \beta_2 * X_2 + \cdots + \beta_k * X_k + \varepsilon_t$$

Where Y is the empirical distance to default (EDD), theoretical distance to default (TDD), empirical probability of default (EPD) or theoretical probability of default (TPD). X contains the market liquidity risk alternative value (Spread), the liquidity coverage ratio (LCR), the net stable funding ratio (NSFR), the current ratio (CR), the gap of MCO ratio (GMCOR), the bad loan ratio (BLR), the capital adequacy ratio (CAR), the loss provision coverage (LPC), the loan to deposit ratio (LDR) and the liquidity reserves ratio (LRR). ε_t is the error term.

4. Empirical Result

In this section, we show the results with different situation and test the hypothesis that developing in section 2.3. Table 7 summarizes the number of observations in this paper. When considering the size effect and time effect, we find that the number of small scale bank is more than big and the number of crisis period is more than after crisis.

Table 7

Number of observations

	Whole Bank	Size Effect		Time Effect					
		Big Scale	Small Scale	Crisis			After Crisis		
				Total	Big	Small	Total	Big	Small
observations	6624	3168	3456	4140	1980	2160	2484	1188	1296

This table summarized the number of observations under different situation in this paper.

4.1 Descriptive Statistics

We observed descriptive statistics of all liquidity indicators that we used in Table 8. We find that the whole bank’s mean of LCR is more than 1 (1.01), implying that the average of whole bank in Taiwan has the necessary assets on hand to ride out short-term liquidity disruptions. But NSFR is less than one (0.88), implying that the average of whole bank in Taiwan maybe has non-stable medium and long-term funding.

Table 8

Descriptive Statistics of whole bank

	μ	σ	σ^2	Max	Median	Min	S.E	Ob.
EDD	51.32	54.83	3006.5	691.16	38.58	0.79	2.02	736
TDD	3.81	2.13	5.54	18.7	3.34	-1.57	0.08	736
EPD	0.00	0.01	0.00	0.22	0.00	0.00	0.00	736
TPD	0.02	0.07	0.01	0.94	0.00	0.00	0.00	736
Spread	-0.02	0.05	0.00	0.12	-0.03	-0.09	0.00	736
LCR	1.01	0.01	0.00	1.03	1.00	1.00	0.00	736
NSFR	0.88	0.36	0.13	7.97	0.86	0.41	0.01	736
GMCOR	-8.67	9.29	86.32	1.85	-5.99	-52.44	0.34	736
LDR	0.82	0.31	0.10	3.92	0.78	0.56	0.01	736
BLR	0.01	0.01	0.00	0.08	0.01	0.00	0.00	736
CR	15.77	6.45	41.66	119.66	15.67	0.63	0.24	736
LRR	0.84	0.31	0.10	3.97	0.79	0.57	0.01	736
CAR	0.96	0.50	0.25	1.89	0.95	0.03	0.02	736
LPC	1.93	2.34	5.49	28.60	1.05	0.00	0.09	736

This table presents the whole bank's mean, standard deviation, variance, maximum, minimum, median, standard error and observations.

4.2 The correlation coefficient

Before the regression analysis, we measure the correlation coefficient between variables first. In table 9, we find that the correlation between LDR and LRR is up to

0.999. And in table 10, we find that the variance inflation factor (VIF) of LDR and LRR are more than 10. Thus, we shave off LRR in our regression function, which has higher VIF.

Table 9

Correlation coefficient

	Spread	LCR	NSFR	GMCOR	BLR	CR	CAR	LPC	LDR	LRR
EDD	-0.148***	0.087**	0.437***	-0.117***	-0.069*	0.225***	-0.005	-0.005	-0.103***	-0.105***
TDD	-0.273***	-0.157***	0.138***	-0.146***	-0.184***	0.064*	0.140***	0.128***	0.004	0.000
EPD	0.000	0.017	0.004	0.036	0.082**	-0.009	-0.032	-0.021	-0.009	-0.008
TPD	0.188***	0.103***	0.012	0.082**	0.182***	0.037	-0.086**	-0.091**	-0.009	-0.006
Spread	1									
LCR	0.085**	1								
NSFR	-0.065*	-0.096***	1							
GMCOR	0.327***	-0.004	0.051	1						
BLR	0.357***	0.409***	-0.031	0.369***	1					
CR	0.075**	0.054	0.007	0.076**	0.235***	1				
CAR	-0.032	-0.674***	0.074**	-0.172***	-0.243***	0.230***	1			
LPC	-0.339***	-0.159***	0.042	-0.359***	-0.474***	-0.279***	-0.066*	1		
LDR	0.051	-0.055	-0.013	0.249***	0.009	-0.321***	-0.275***	-0.022	1	
LRR	0.060	-0.047	-0.012	0.259***	0.032	-0.314***	-0.280***	-0.036	0.999***	1

This table presents the correlation coefficient between the respective variables. Among them, the correlation of LCR, NSFR and spread are significant and as expected between EDD. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 10

Variance inflation factor (VIF)

	Multicollinearity statistics		
	Total Bank	Big Scale	Small Scale
Spread	1.254	1.419	1.291
LCR	2.737	2.293	1.512
NSFR	1.027	1.831	1.022
GMCOR	1.540	3.582	1.622
LDR	1418.369	61.149	6067.530
BLR	2.487	2.856	4.491
CR	1.326	2.095	1.368
LRR	1422.936	60.263	6056.699
CAR	2.783	2.218	1.672
LPC	1.609	2.225	1.508

This table presents the VIF of the variables. If VIF is more than 10, we conclude that have collinearity.

4.3 Regression analysis

Next, we carried out the regression analysis. On the whole banks, the preliminary result in table 11 showed that the model using EDD is the best, and the secondly is TDD. Why the result by using EPD and TPD are not significant? To the best of our knowledge, the reason maybe is no matter the gap distance large or small, converting to the probability fail to capture differences for each other. Thus, we choose the result by use EDD and just against this to analysis. However, the result under the EDD showed that all liquidity risk indicators are significant, excluding LDR. This implies that spread, the new liquidity risk indictors and traditional liquidity risk indictors are able to effectively explain the bank failures. The adjusted R-square is about to 0.3. Moreover, we also employed regression model with remain LRR and shave off LDR. The result is the same. Thus, our hypothesis 1 holds. Apart from this, we regards the Spread as systemic risk of liquidity risk, LCR and NSFR as non-systemic risk of liquidity risk, the others as control variables, and we further investigate which one is major liquidity risk source. Because that we major concern the effectiveness of spread and new liquidity risk indictors, the following description will focus on Spread, LCR and NSFR.

Table 11

Regression analysis result on the whole bank

	EDD	TDD	EPD	TPD
Spread	-87.38**	-8.71***	-0.01	0.20***
LCR	1136.45**	-28.87	-0.11	-0.05
NSFR	68.77***	0.68***	0.00	0.01
GMCOR	-0.72***	-0.02*	0.00	0.00
BLR	-670.62***	-9.43	0.10**	0.69**
CR	2.25***	0.04***	0.00	0.00
CAR	-9.63*	0.20	-0.00	-0.01
LPC	-1.88**	0.02	0.00	0.00
LDR	0.63	0.58	0.00	-0.01
Adj.R-Square	0.30	0.12	-0.00	0.04

This table presents the whole bank's regression result. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

4.4 Size effect

Because that the average performance will be affected by bank's constitution. In order to avoid the gap is too large, in this paper, we divided the bank to big scale and small scale. If bank's total assets is less than NT$ 1 trillion, classified as small scale, if bank's total assets more than NT$1 trillion, classified as big scale. Table 12 is the size classification with our sample banks. Table 13 shows the descriptive statistics under the size effect. We find that mean of spread, LCR and NSFR didn't differ between the big and small scale banks, while mean of big scale bank's EDD is lower than small, but the small scale bank's standard deviation of EDD is larger than big. In addition, the observations in small scale bank is more than big. Table 14 presents the regression result with EDD under the size effect. The result under the EDD showed that the spread, LCR and NSFR are significant in big scale but only NSFR is significant in small scale, and the R-square is 0.43 and 0.36, respectively. In other words, the big scale banks have high sensitivity and high market influence. Therefore, the big scale banks are affected by both non-systemic and systemic risk, whereas the small scale banks are just affected by non-systemic. Thus, our hypothesis 2 also holds.

Table 12

Size classification of sample bank

Sample bank name under the size effect	
Big scale (Total assets > NT$1 trillion)	Small scale (Total assets < NT$1 trillion)
Chang Hwa Bank	King's Town Bank
Hua Nan Bank	Bank of Kaohsiung
Cathay United Bank	Union Bank of Taiwan
Mega International Commercial Bank	Ta Chong Bank
Bank SinoPac	China Development Industrial Bank
First Bank	Shin Kong Bank
Taiwan Business Bank	Taichung Bank
TaipeiFubon Bank	KGI Bank (former Cosmos Bank)
E.Sun Bank	Far Eastern International Bank

Taishin International Bank	Entie Commercial Bank
CTBC Bank	Yuanta Commercial Bank
	JihSun International Commercial Bank

This table presents the big and small scale bank name of our sample. If bank's total assets is more than NT$1 trillion, it is classified to big scale. On the contrary, if less than NT$1 trillion, it is classified to small scale.

Table 13

Descriptive Statistics under the size effect

	μ	σ	σ^2	Max	Median	Min	S.E	N
Big Scale								
EDD	47.63	41.69	1738.1	385.06	37.97	3.12	2.22	352
TDD	4.25	2.08	4.33	14.70	3.83	0.70	0.11	352
N(-EDD)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	352
N(-TDD)	0.01	0.03	0.00	0.24	0.00	0.00	0.00	352
Spread	-0.02	0.05	0.00	0.12	-0.03	-0.09	0.00	352
LCR	1.00	0.00	0.00	1.00	1.00	1.00	0.00	352
NSFR	0.89	0.22	0.05	2.69	0.92	0.41	0.01	352
GMCOR	-8.52	9.94	98.78	1.32	-5.16	-52.4	0.53	35

						4		2
LDR	0.79	0.08	0.01	1.03	0.78	0.61	0.00	352
BLR	0.01	0.01	0.00	0.03	0.01	0.00	0.00	352
CR	16.53	3.86	14.91	34.05	15.58	9.84	0.21	352
CAR	1.38	0.32	0.10	1.89	1.28	0.44	0.02	352
LPC	1.87	1.80	3.24	10.68	1.10	0.35	0.10	352
Small Scale								
EDD	54.70	64.44	4152.9	691.16	39.08	0.79	3.29	384
TDD	3.40	2.09	4.38	18.48	2.96	-1.57	0.11	384
N(-EDD)	0.00	0.01	0.00	0.22	0.00	0.00	0.00	384
N(-TDD)	0.03	0.09	0.01	0.94	0.00	0.00	0.00	384
Spread	-0.02	0.05	0.00	0.12	-1.03	-0.09	0.00	384
LCR	1.01	0.00	0.00	1.03	1.01	1.00	0.00	384
NSFR	0.88	0.45	0.20	7.97	0.83	0.55	0.02	384
GMCOR	-8.80	8.67	75.09	1.85	-6.99	-37.06	0.44	384
LDR	0.86	0.42	0.18	3.92	0.78	0.56	0.02	384
BLR	0.02	0.01	0.00	0.08	0.01	0.00	0.00	384
CR	15.07	8.08	65.27	119.66	15.87	0.63	0.41	384
CAR	0.57	0.26	0.07	1.07	0.54	0.03	0.01	384

LPC	1.99	2.75	7.57	28.60	1.03	0.00	0.14	384

This table presents the mean, standard deviation, variance, maximum, minimum, median, standard error and observations under the size effect.

Table 14

Regression analysis result with EDD under the size effect

	EDD	
	Big Scale	Small Scale
Spread	-97.89***	-28.33
LCR	7399.96**	811.36
NSFR	32.70*	72.64***
GMCOR	-0.10	-1.83***
BLR	-881.90**	-621.13***
CR	5.72***	1.34***
CAR	1.72	-14.42
LPC	1.28	-3.08***
LDR	139.95***	-7.07
Adj.R-Square	0.43	0.36

This table presents the regression result with EDD under the size effect. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

4.5 Time effect

In addition to the bank's constitution will affect the average performance, the different sample period maybe will. The sample period in this paper contains the crisis period and after crisis period. Thus, we divided the sample period into two period, 2006-2010 is the crisis period, and 2011-2013 is after crisis period. We investigate whether they have different result in different period. Table 15 shows the descriptive statistics under the time effect. We find that the mean of spread in crisis period is larger than after crisis, while the mean of NSFR in crisis is lower than after crisis. In addition, the observations and the mean of EDD in crisis is larger than after crisis. Table 16 presents the regression result with EDD under the time effect. The result under the EDD showed that LCR is significant for whole banks in crisis period. That is to say whole banks can have a higher proportion of high-quality liquid assets thereby reduce the impact of liquidity risk. After the crisis, the spread, LCR, NSFR are become significant, and R-square is rising from 0.16 to 0.6. Thus, the whole banks are just affected by non-systemic in crisis period, whereas the whole banks are affected by both non-systemic and systemic risk after the crisis. And we conclude that R-square in crisis period pulled down the whole R-square. Therefore, our hypothesis 3 also holds.

Table 15

Descriptive Statistics under the time effect

	μ	σ	σ^2	Max	Median	Min	S.E	N
Crisis								
EDD	41.50	32.95	1085.8	189.43	33.72	0.79	1.54	460
TDD	3.38	1.91	3.65	18.48	3.05	-1.57	0.09	460
N(-EDD)	0.00	0.01	0.00	0.22	0.00	0.00	0.00	460
N(-TDD)	0.03	0.08	0.01	0.94	0.00	0.00	0.00	460
Spread	0.00	0.06	0.00	0.12	0.00	-0.09	0.00	460
LCR	1.01	0.01	0.00	1.03	1.01	1.00	0.00	460
NSFR	0.86	0.24	0.06	4.49	0.84	0.41	0.01	460
GMCOR	-4.67	5.94	35.26	1.85	-2.63	-34.89	0.28	460

BLR	0.02	0.01	0.00	0.06	0.02	0.00	0.00	460
CR	16.43	7.38	54.24	119.66	16.10	0.63	0.34	460
CAR	0.94	0.49	0.24	1.89	0.95	0.03	0.02	460
LPC	0.91	0.64	0.41	3.95	0.72	0.18	0.03	460
LDR	0.85	0.38	0.15	3.92	0.78	0.56	0.02	460
After Crisis								
EDD	67.69	76.11	5793.0	691.16	47.07	3.79	4.58	276
TDD	4.51	2.29	5.24	14.70	3.89	-0.33	0.14	276
N(-EDD)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	276
N(-TDD)	0.01	0.04	0.00	0.63	0.00	0.00	0.00	276
Spread	-0.05	0.01	0.00	-0.04	-0.05	-0.06	0.00	276
LCR	1.01	0.00	0.00	1.02	1.00	1.00	0.00	276
NSFR	0.93	0.5	0.25	7.97	0.90	0.41	0.03	276
GMCOR	-15.33	10.03	100.52	-0.29	-13.86	-52.44	0.60	276
BLR	0.01	0.01	0.00	0.08	0.00	0.00	0.00	276
CR	14.67	4.29	18.37	26.53	15.21	1.17	0.26	276
CAR	0.99	0.50	0.25	1.89	0.95	0.03	0.03	276
LPC	3.64	3.06	9.34	28.60	2.81	0.00	0.18	276
LDR	0.78	0.11	0.01	1.56	0.78	0.57	0.01	276

This table presents the mean, standard deviation, variance, maximum, minimum, median, standard error and observations under the time effect.

Table 16

Regression analysis result with EDD under the time effect

	EDD	
	Crisis	After Crisis
Spread	-33.25	-4279.93***
LCR	1103.14***	2322.07**
NSFR	9.59	82.17***
GMCOR	-0.02	-0.58
BLR	-247.65	36.32
CR	1.13***	7.88***
CAR	4.70	-24.60**
LPC	-10.60***	-0.30
LDR	-2.35	153.64***
Adj.R-Square	0.16	0.60

This table presents the regression result with EDD under the time effect. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

4.6 Size effect & time effect

Finally, under the size effect and time effect in table 17, the result under the EDD in crisis period showed that spread and LCR are significant in big scale banks, but three indicators are all not significant in small scale banks. That is, the big scale banks have high market influence but small scale banks are not. When crisis break out, big scale banks are playing an important role to hold on whole market. While the reason for the spread is significant in big scale but not in whole banks under the time effect maybe is that the amount of the small scale banks are more than big. Moreover, LCR is significant in big scale but not in small represents big scale bank's LCR is the most important indicator in crisis period. In the other words, if big scale banks have a higher proportion of high-quality liquid assets, the impact of crisis on whole will be reduced. After crisis, both big and small scale are affected by spread, while NSFR is significant in small scale. Therefore, for big scale banks, LCR is more important than NSFR, but for small scale banks, NSFR is more important.

Table 17

Regression analysis result with EDD under the size effect and time effect

	EDD			
	Crisis		After Crisis	
	Big Scale	Small Scale	Big Scale	Small Scale
Spread	-52.93**	4.73	-3292.09***	-4956.54***
LCR	5016.47**	163.29	35594.15***	1607.84
NSFR	7.14	-5.11	19.58	82.67***
GMCOR	1.22***	-2.03***	-0.16	-0.87
BLR	-773.75**	-137.01	11700.20***	43.36
CR	5.74***	0.29	-0.09	8.52***
CAR	7.98	7.60	5.14	-58.54*
LPC	1.01	-14.02***	3.19	0.13
LDR	32.67	-4.02	171.15***	122.98**
Adj.R-Square	0.64	0.21	0.56	0.63

This table presents the regression result with EDD under the size effect and time effect. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

5. Conclusions and recommendations

This paper develops three hypotheses to investigate whether the liquidity risk indicators: LCR and NSFR (non-systemic liquidity risk) based on BCBS liquidity specification and Spread (systemic liquidity risk) can effectively predict defaults for banks in Taiwan and the effectiveness of liquidity risk indicators under the different size and time period.

The empirical results show that no matter the new liquidity risk indictors that proposed in Basel III, the market liquidity risk alternative value (Spread) or the traditional liquidity risk indicators that based on PSLRMS have a significant impact in respect to whole banks. That is to say existing liquidity risk indicators can effectively measure liquidity risk. This result is different from Wu and Hong (2012) and Wan- Hsuan Lee (2014). We also find that, the liquidity risk source is major from non-systemic on the whole banks. Under the size effect, the big scale banks are affected by both non-systemic and systemic risk, whereas the small scale banks are affected by non-systemic. Under the time effect, the whole banks are affected by non-systemic in crisis period, whereas the whole banks are affected by both non-systemic and systemic risk after the crisis. Therefore, our three hypotheses all hold. While under the size effect and time effect, we find that LCR of the big scale banks is the most important indictor to hold the whole financial system in the crisis period. Thus, this finding lead us to believe that the impact of non-systemic liquidity risk is large than systemic liquidity risk. In other words, if all banks have very stable constitution and have outstanding liquidity risk indicators, non-systemic liquidity risk will dominate systemic liquidity risk in the crisis period and then stabilize the whole market.

Despite the encouraging results of this study as to the positive effect of predicting the default of bank, future research is required in a number of directions. Actually, the results in this paper are not accurate enough. Limited to the provisions have no clear interpretation and some of data in Basel III guidelines unable to obtain in public information, partial of variables are using approximation to measure in this paper. However, it is very difficult to gain the complete and immediate data in public information now. Despite this, it is hoped that it can serve as a basis for further study.

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