AN INVESTIGATION INTO BANK BEHAVIOUR UP TO THE 2007-08 GLOBAL FINANCIAL CRISIS

By

YI JIN

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Department of Economics

Birmingham Business School

College of Social Sciences

The University of Birmingham

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ABSTRACT

This thesis includes four empirical studies on the effects of bank behaviour on bank performance in European and North American countries up to the 2007-08 financial crisis. First, we investigate the effects of non-traditional bank activities, i.e., off-balance-sheet (OBS) items, and traditional activities, i.e., loans, on bank performance, and then, considering a risk-based capital requirement, show an optimal bank portfolio. Second, we examine the impact of interbank lending on bank risk-taking, considering the consequence of "Too big to fail" (TBTF) and show differences in bank activities and risk-taking between large and small banks. We then study the effect of changes in bank behaviour on the determinants of interest margins. Finally, we identify the reasons of individual bank failure towards understanding the mechanism of the recent financial crisis. Our empirical findings provide the following results. First, the negative effect of OBSs on bank performance is found and banks prefer moving away from OBSs, given the risk-based capital requirement. Second, interbank lending increases the large banks' risk level under TBTF. Third, product diversification has a negative impact on interest margins. Finally, the housing price index has a significant impact on the probability of bank failure in the context of the recent financial crisis.

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Any remaining errors are mine.

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LIST OF ABBREVIATIONS

CB	Central Bank
CDO	Collateralised Debt Obligation
CDS	Credit Default Swap
CPI	Consumer Price Index
CR	Capital Requirement
ECB	European Central Bank
EU	European Union
GDP	Gross Domestic Product
GLS	Generalized Least Squares
HS	Hausman Statistic
H-statistic	Herfindahl index
IMF	International Monetary Funds
IV	Instrumental Variable
LLP	Loan Loss Provision
LLR	Lender of Last Resort
MBS	Mortgage Based Securities
NER	Net Expected Return
NII	Non-Interest Income
NIM	Net Interest Margins
OBS	Off-Balance-Sheet items
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
ROA	Return on Assets
SR	Sharpe Ratio
TA	Total Assets

TBTF	Too-Big-To-Fail
2SLS	Two Stage Least Squares

CHAPTER 1

INTRODUCTION

The existence of the banking industry is a major outcome from the development of modern society. The positive effect of bank behaviour has been observed and applied in the various areas of economy. Smith (1776[1937], p305) pointed out a basic economic function of banks:

> *"The judicious operation of banking, by substituting paper in the room of a great part of this gold and silver, enables the country to convert a great part of this dead stock into active and productive stock; into stock which produces something to the country."*

In this respect, banks as an intermediary can maximise profits, by their nature, which is of importance not only for individuals' finances, but also for countries' development. On the other hand, the debate related to the bank sector is still on-going and even becoming prominent, considering the financial crisis 2007-08 that is still significant in the developed countries. This has been a main motivation for calls for a comprehensive investigation into bank behaviour. Therefore, this thesis provides a study on the effect of bank behaviour on bank performance up to the recent financial crisis.

1.1 The Importance of Bank Behaviour

What does a bank do? The answer to this question varies country by country, owing to the different legal systems; however, the common argument is that a bank plays an intermediary role between taking deposits and granting loans in order to reallocate capital in the economy (Heffernan, 2005). In contemporary banking theory, the economic functions of banks include the intermediary role, the transformation of assets, the liquidity service and risk management (Freixas and Rochet, 2008, p2).

The basic function of banks is an intermediary role in reallocating capital in the economy. Because of the economies of scale, banks can lower operational costs when facing a large amount of lending and depositing; moreover, the information economies of scope enable bank lending to be costless compared with other institutions, since banks can access more privileged information on borrowers (Heffernan, 2005, p3). Stiglitz and Weiss (1988) suggest that, although firms can finance in a convenient way by issuing bonds, external funds from banks can be used as a signal of the credits of borrowers. Since the 1980s, many banks in the developed countries have adopted a universal banking model that is a combination of commercial and investment banks, so non-traditional activities[1] have become prevalent. However, taking the recent financial crisis into consideration, non-traditional activities are coupled with higher risk-taking, given inappropriate bank regulation, which leads to an unstable financial market. Thus, an application of a universal banking model has raised

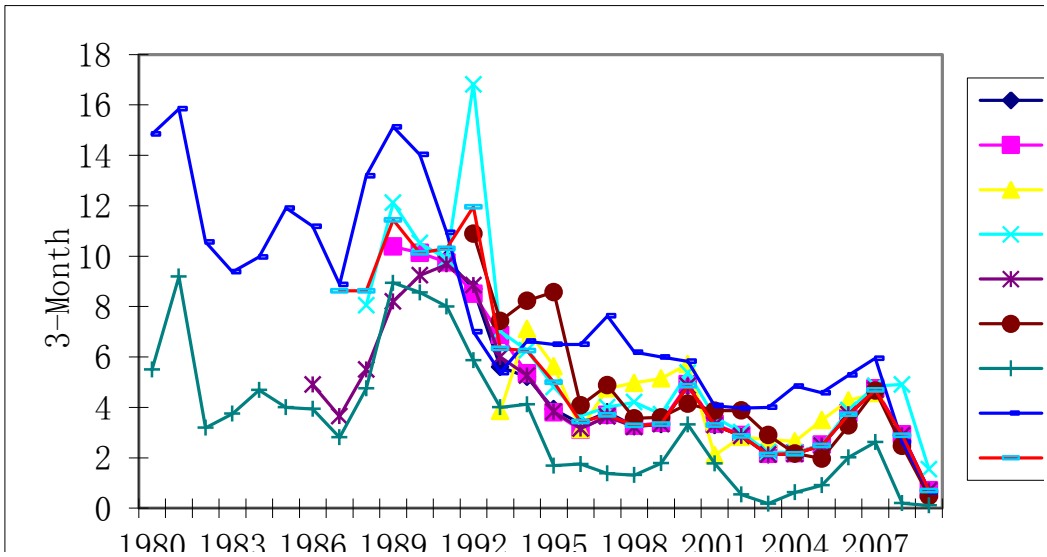
[1] Non-traditional activities contain off-balance-sheet items, such as speculation through derivatives and hedging activities, and financial trading, such as selling of financial services, insurance and mobile phone. These activities can be measured by trading revenues and commissions and fees, respectively.

concerns as to whether the diversification is safe or not and, furthermore, what an optimal bank portfolio is, based on traditional and non-traditional activities.

Another core activity provided by banks is a liquidity service, which is an important function that can distinguish banks from other institutions, as suggested by Heffernan (2005). The public has different liquidity preferences. As a bridge, banks tend to satisfy the liquidity requirement of both savers and borrowers. A bank lends liquidity to a firm, which is usually financed by deposits. Generally, the maturity of deposits is shorter compared with loans. This implicitly indicates that the liquidity preferences of borrowers and savers are simultaneously satisfied through this bank service. In addition, the allocation of liquidity is not restricted between banks and non-financial institutions. The interbank lending offers a chance for banks with a shortage of liquidity to borrow from other financial institutions, and the interbank rate can be an indicator of market risk, especially in a downturn, when an increase in interbank assets might lead to a higher risk level of lending banks, so they demand a higher interbank rate. Figure 1-1 displays interbank rates (3-month) in the developed countries[2] over time, and generally shows a decline of the interbank rate until 2006 in order to support the refinance of problematic banks through the interbank market, while it slightly increased since 2007, following the scenario in the financial markets (financial crisis 2007-08) that lending banks demanded a higher rate for fear that borrowers were unable to repay.

[2] These developed countries in Europe and North America are the sample in this thesis, while they may vary in each chapter due to data availability.

Figure 1-1 Interbank Rate (3-month)

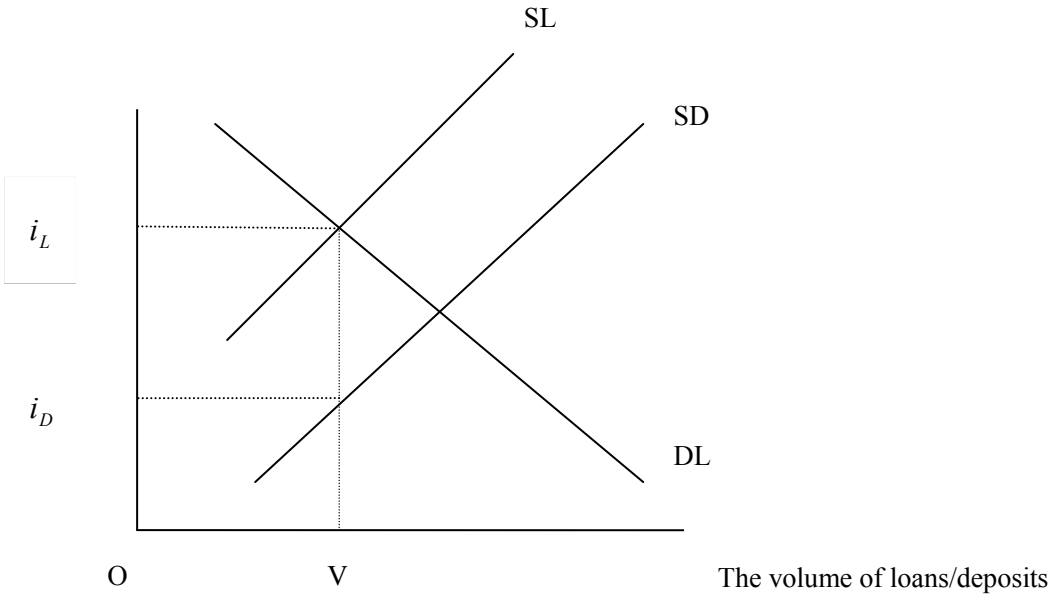


Source: Datastream
Data of the US is not available.

Considering the basic function of bank activities, banks have to face the challenge of risk-taking. In Figure 1-2, SL is the supply of loans, SD is the supply of deposits and DL is the demand of loans. As mentioned above, owing to the information economies of scope, banks can monitor the risk level of borrowers and charge a risk premium (a loan rate i_L), banks also pay a deposit rate i_D and the difference between the deposit rate and loan rate is the interest margin, which can offset various costs including operation costs, intermediation costs and risk premiums, and OV is the volume of the supply of loans and deposits in equilibrium (Heffernan, 2005 p2). However, a change in interest rates makes costs from short-term funding higher than interest income from long-term loans. Thus, the volatility of interest rates requires higher interest margins to cover the additional costs (Ho and Saunders, 1981). In addition, considering greater competition in traditional credit markets, product diversification may increase non-traditional activities associated with non-interest income to

offset the losses from traditional activities (intermediary role), leading to a lower interest income, as suggested by the theoretical model of Valverde and Fernández (2007). Therefore, we may argue that not only traditional interest risk but also a change in bank behaviour has an impact on interest margins, considering the development of financial markets.

Figure 1-2 Intermediation and Interest Margins



1.2 The Development of the Banking Industry

During the past three decades, the banking industry of industrial countries has experienced significant changes to achieve efficiency and profitability. The root of these changes is that, banks would like to maximise returns at lower costs, thus, the banking industry presented a trend in the diversification of financial services and consolidation of financial institutions prior to the financial crisis in 2007-08. Figure 1-3 displays net interest income from 1980 to

2009. Overall, it does not suggest any significant change other than in the US; moreover, France, Denmark and Belgium experienced a slight decline since 1990. This may indicate that banks in the developed countries moved away from traditional intermediation to non-traditional financial services, i.e., off-balance-sheet activities, in order to earn non-interest revenue, owing to deregulation and greater competition in traditional credit markets (Mishkin, 2002, p274). In Europe, the Second Banking Coordination Directive has been addressed since 1993, which allows banks to be involved in both traditional activities and non-traditional activities; in the US, Gramm-Leach-Bliley Act was proposed in 1999, removing barriers between commercial banking and investment banking. The application of a universal banking model changes the bank income structure towards non-interest income. Figure 1-4 shows the ratio of net non-interest income to total income. Compared with net interest income, the non-interest income increased significantly for all countries until 2006, in general. The rapid growth of off-balance-sheet activities played an important role in the rise of non-interest income. Since 2007, there has been a decline in non-interest income, which is consistent with the situation of the financial markets. Many economists (see Stiroh, 2002, 2006; Saunders and Walter, 1994; Welfens, 2008; DeYoung and Roland, 2001; Demirgçü-Kunt and Huizinga, 2009) point out that a large involvement of new lines of financial businesses leads to higher risk-taking, further causing bank failure and financial instability. Table 1-1 presents the number of listed banks in 10 countries. We find that the largest number of listed banks dominates the US financial market partly due to the serious regulation that restricted the establishment of branches (Mishkin, 2002, p248). Switzerland as

one of the important financial centres appears in second place. Generally, European financial markets, i.e., the UK, have been dominated by 5 largest listed banks, including HSBC, Barclays, Standard Chartered, Lloyds Banking Group and Royal Bank of Sctl (Datastream); in the US, although a large number of financial firms had existed since the 1980s, this decreased owing to a national consolidation through which banks could increase their size in order to benefit from the economies of scale (Mishkin, 2002, p256).

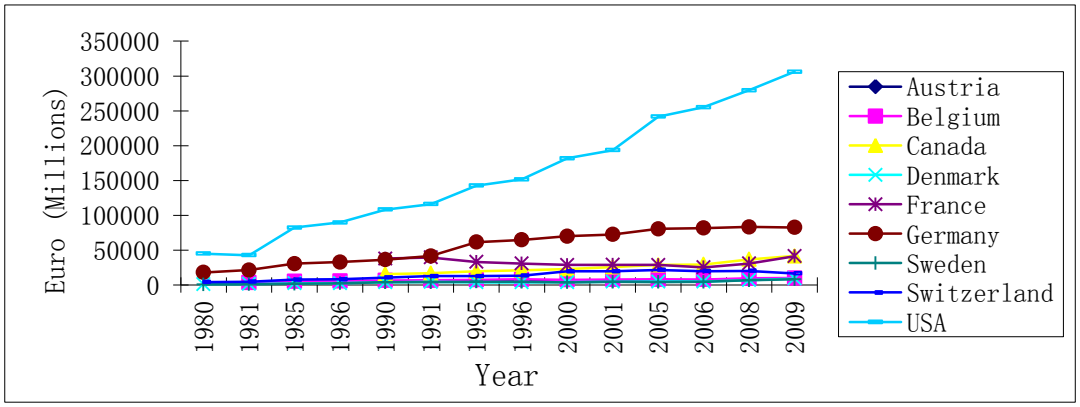
One of the causes of these changes is the development of financial systems. Compared with the past 30 years, the financial system has undergone a reform that has been rarely seen before. The improvement of bank management and application of advanced technology enable banks and non-financial firms to access information easily. On one hand, this encourages non-financial institutions to be involved in financial services, further increasing competitiveness (Canals, 2006, p329); on the other hand, in this context, banks move away from traditional activities to non-traditional activities to achieve higher revenue (non-interest income) because of the greater competition in traditional credit markets (ECB, 2008).

The alternative reason for the changes is financial market competition. Financial liberalisation plays an important role in generating higher competition. A rise in the number of new branches of foreign financial institutions has reduced the market shares of domestic banks. Therefore, increasing competition forces banks to engage in new financial products. Diversification is a major approach to reduce operation costs; however, Canals (2006) points

out that some banks considered the switching costs from traditional bank activities to new activities, so they still concentrate on traditional behaviour but make an effort to improve the efficiency of financial operations. Thus, in these cases, banks have more incentive to become large through consolidation in order to benefit from the economies of scale.

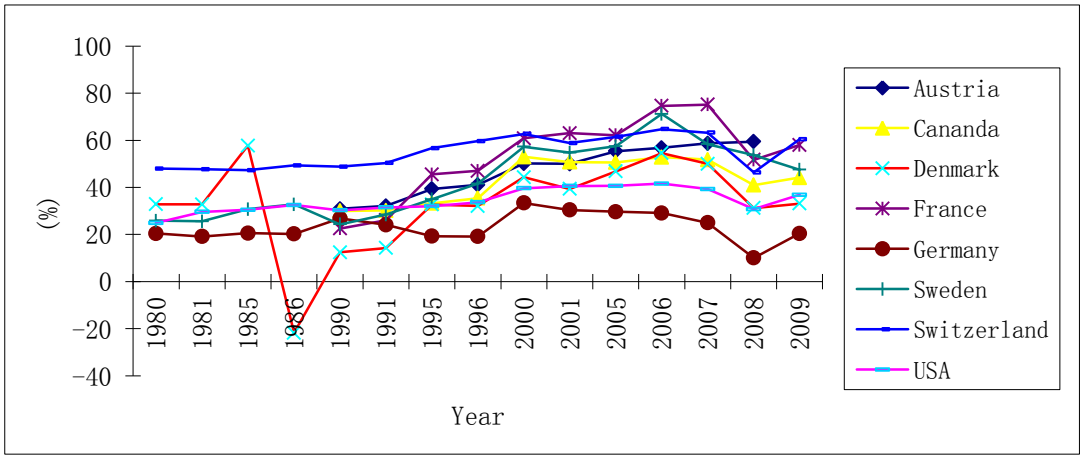
As indicated by Heffernan (1995), bank regulation and supervision may contribute to the development of the banking industry. Following the Basel Capital Accord proposed in 1988 and 2004, banks have to increase the amount of capital holding against potential risk-taking as a regulatory cost, which might have a negative impact on bank profitability. Therefore, governments propose deregulation to lower operation costs and encourage banks to become involved in diversification. On the other hand, regulators have to face challenges from new lines of financial businesses with complex characteristics. Taking the recent financial crisis 2007-08 into consideration, Basel III agreed by the Basel Committee in 2010-11 mainly focuses on bank liquidity and bank leverage in order to control for the risk level of securitisations (Bank for International Settlements, 2011).

Figure 1-3 Net Interest Income of Banking Sector from 1980 to 2009



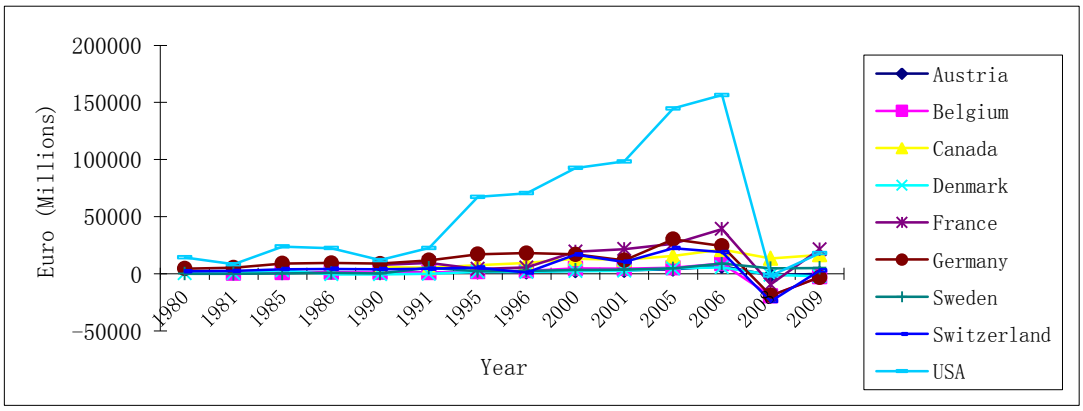
Source: OECD.StatExtracts: Finance: Bank profitability Statistics.
Data of the UK is not available.

Figure 1-4 Ratio of Non-interest Income to Total Income from 1980 to 2009



Source: OECD.StatExtracts: Finance: Bank profitability Statistics.
Data of the UK is not available. Data of Belgium is too small to be compared with other countries so that it cannot be presented in one graph.

Figure 1-5 Income before Tax from 1980 to 2009



Source: OECD.StatExtracts: Finance: Bank profitability Statistics.
Data of the UK is not available.

Table 1-1 The Number of Listed Banks (1988-2009)

Year / Country	1980-1987[3]	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Austria	NA	3	3	3	3	3	4	4	4	4	4	5	5	5	5	5	5	5	6	6	6	6	6
Belgium	NA	2	2	2	2	2	2	2	2	3	3	3	3	3	4	4	4	4	4	4	4	4	4
Canada	NA	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Denmark	NA	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
France	NA	2	3	3	3	3	5	5	5	6	6	7	7	7	7	8	8	8	8	8	9	9	9
Germany	NA	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	6	6	6
Sweden	NA	2	2	2	2	2	2	2	3	4	4	4	4	4	4	4	4	4	4	4	4	4	5
Switzer-land	NA	6	11	13	13	13	14	14	15	15	15	16	16	16	17	18	18	18	18	19	19	19	19
The UK	NA	3	3	3	3	3	4	4	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5
The USA	NA	20	21	21	21	23	23	24	24	25	25	25	28	28	28	28	28	28	30	30	30	32	32

Source: Datastream

[3] Data from 1980 to 1987 is not available for all sample countries.

1.3 Study Questions

The main motivation for this thesis stems from the recent financial crisis in 2007-08, which initially occurred in the US and spread to other countries. In 2007, the US experienced a decline in national wealth and deterioration in the credit market. A decrease in housing prices led to a large number of defaults by borrowers with less credit (Reinhart and Rogoff, 2008). The new lines of financial products with non-transparent characteristics aggravated this situation by increasing volatilities, though theoretically this can provide risk-sharing. This gives rise to a debate on the issue of whether traditional activities and non-traditional activities should be separated, which has prevailed among financial studies recently. Besides this, many researchers have pointed out that an inappropriate regulation of non-traditional activities with non-transparent and complicated characteristics is one of the reasons for the recent financial crisis. In addition, the contagion risk in this financial event has been emphasised, since the failure of a key bank may result in a banking panic, especially in the context of the interbank markets, where banks with illiquidity borrow from others with sufficient liquidity. On one hand, the default of a borrowing bank may put the lending bank at risk, particularly in a downturn; hence, in this case the central bank as a lender of last resort (LLR) is willing to rescue the lending bank if it is in a key position, i.e., money centre bank (too-big-to-fail, TBTF) in order to maintain a stable financial system and enhance public confidence; on the other hand, a moral hazard problem is generated from LLR intervention, which provides an opportunity for banks to engage in risky activities, potentially implying that regulation does not work for big banks; LLR also encourages all banks to make an effort to be large by increasing the capacity of bank activities in order to benefit from TBTF; while the expansion of bank activities, especially non-traditional activities, may increase the volatilities of bank returns. Figure 1-5 displays bank income over time, which does not show

a significant increase other than in the US, despite an increase in non-interest income (see Figure 1-3); since 2007, all countries experienced a decline in bank returns, especially in the US, due to the financial crisis. In addition, the recent financial crisis highlights the effect of macro-shocks, especially housing prices. As mentioned before, the return of financial derivatives, i.e., Credit Default Swaps (CDS) and Mortgage Based Securities (MBS), related to mortgages and subprimes, depends on housing prices. When housing prices go down, the default of these financial products starts. Empirical evidence from Hegen and Ho (2007), Godstein et al. (2000) and Demirguc-Kunt and Detragiache (1998, 1999) implies that interest rate risk, GDP, M2 and international trade should be considered to predict banking crises, the banking crisis preceded economic recession, and therefore, can be predicted by these economic indicators. However, they do not show analyses on the effect of housing prices. Overall, we find that bank diversification with a risky product line, inappropriate bank regulation, moral hazard resulting from TBTF in the context of the interbank markets, fundamental bank risk-taking and macro-shocks are possible reasons for the financial crisis of 2007-08; therefore, this thesis aims to investigate bank behaviour surrounding these issues. The lessons drawn from the investigation are essential to design a desirable bank regulation that influences bank activities *ex ante* in the run-up to a crisis (Llewellyn, 2003). The research questions are as follows:

- Off-balance-sheet activities have been enhanced during the last 30 years, and the benefits of bank diversification also have been observed. However, is there any negative effect of off-balance-sheet activities on bank performance that should be considered, particularly in the context of the recent financial crunch? In other words, how should banks choose an optimal portfolio by combining traditional activities with non-traditional activities?

- The interbank market is used efficiently to provide credit for banks with a shortage of liquidity. Nevertheless, it may give rise to higher risk-taking by large banks during downturns, since large banks are inclined to engage in risky assets under TBTF. Thus, we attempt to examine the question: does an increase in interbank lending lead to higher risk-taking of banks, particularly considering the bank size effect?

- Although interest rate risk has been found to be a main factor affecting interest margins, the introduction of financial innovation, i.e., product diversification, may have an impact on interest income structure and interest margins. Thus, we would like to investigate the effect of a change in bank behaviour on the determinants of interest margins.

- The financial crisis in 2007-08 initially stemmed from individual bank failure, thus, it is necessary to consider the bank-level and macro-level variables as candidates to examine the reasons for bankruptcy. Therefore, the last question in the thesis is why some banks exhibit failure while others do not.

1.4 Outline of the Thesis

This thesis combines four empirical studies on off-balance-sheet activities, interbank lending, interest margins and interest rate risk, and bank failure at the bank and country levels. The empirical chapters are based on developed countries in Europe and North America, including the run-up to the recent financial crisis and the episode of the crisis. The remainder of the thesis is organised as follows:

Chapter 2 starts by identifying the effect of off-balance-sheet activities and traditional activities, i.e., loans, on bank performance on the basis of a standard portfolio theory and portfolio theory considering credit rationing in traditional credit markets, in order to show an optimal bank portfolio; we also examine the effect of a risk-based capital requirement on banks' strategy for choosing an optimal portfolio on the basis of the theoretical work on maximising banks' expected return with and without the capital requirement, respectively.

Chapter 3 discusses the effect of interbank lending on the risk-taking of banks in terms of two bank groups determined by bank size, endogenously chosen using the threshold method of Hansen (2000) and Caner and Hansen (2004). We modify Dinger and Hagen's (2005) model by considering the effect of "too big to fail" suggested by Freixas et al. (2000), in order to identify differences in bank risk-taking and activities between large and small banks.

In Chapter 4, on the basis of the dealership model of Ho and Saunders (1981) and the multi-product bank model of Valverde and Fernández (2007), we examine the effect of changes in bank behaviour up to the recent financial crisis on the determinants of interest margins by controlling for institutional imperfections, such as implicit payment, opportunity

cost and capital ratio, using the Two-Stage-Least-Squares (2SLS) method. We provide a country-by-country study in the context of interest margins under the heterogeneous assumption identified by a robustness test.

In Chapter 5, we firstly identify the main causes, including bank- and macro-level candidates, that lead to bank failure using a logit model, on the basis of the modified theoretical model of Gonzalez-Hermosillo (1999) by considering product diversification and size effect. Then, after controlling for the country specific effect, the empirical work shows the role of product diversification in determining the probability of bank failure for each country. Finally, we respectively identify the reasons for bank failure in the run-up to the recent financial crisis and the crisis period.

In Chapter 6, we provide a summary of the answers to the four questions, and indicate the main conclusions based on the empirical results. Comments on possible future research are also given.

CHAPTER 2

THE OPTIMAL BANK PORTFOLIO SELECTION BASED ON THE EFFECT OF OFF-BALANCE-SHEET ITEMS AND LOANS

2.1 Introduction

Since the 1980s, employment of non-traditional bank activities has emerged among financial institutions owing to an increase in the competition level of financial markets. As shown by Figures 1-4 and 1-5 in the Introduction, the ratio of non-interest income rose in the developed countries before 2008, while total bank income did not show a significant increase over time (other than in the US). The changes mentioned above have an impact on bank income structure and the range of bank activities, suggesting that a universal banking model is acceptable in the developed countries. However, an increase in non-traditional activities, i.e., off-balance-sheet items, might be associated higher risk-taking, especially considering the collapse of derivative markets and securitisations leading to the financial crisis in 2007-08: this enables us to question the positive effect of off-balance-sheet items (OBSs) on bank performance.

The empirical research regarding this issue suggests that the effect of OBSs can be either positive or negative: an increase in OBSs generates a higher level of return and reduces the

capital regulatory costs, and the application of a universal banking model enables banks to diversify risk-taking, while OBSs associated with higher leverage lead to significant volatilities of bank returns, which potentially implies that traditional banking activities cannot be completely replaced by non-traditional activities. Banks should be cautious about choosing an investment portfolio, especially regarding OBSs. Nevertheless, most studies (see Stiroh, 2006; Stiroh and Rumble, 2006; Stiroh, 2004; Stiroh, 2002; DeYoung and Roland, 2001) are based on US financial institutions, which cannot be applicable in other countries' markets, particularly the European financial market, because of differences in bank regulation and the structure of the banking industry. Non-interest income, as a measure of non-traditional bank behaviour, has been investigated in previous papers; however, they do not show an optimal bank portfolio selection regarding both non-traditional activities, i.e., OBS items, and traditional activities, i.e., loans, especially in the context of the recent financial crisis. In addition, risk-based capital regulation has an impact on the composition of bank portfolios, since banks have to take the regulatory costs for risky assets into account. Therefore, the lack of evidence mentioned above makes it interesting to investigate the effects of OBSs and loans on bank performance and how to choose an optimal portfolio under a risk-based capital regulation, bearing in mind data on banks not only in the US, but also in European countries.

The structure of this chapter is organised as follows: both a theoretical and empirical review are introduced in Section 2; we present a description of the data in Section 3; the model specification and variables are shown in Section 4; an introduction to the econometric methodologies is presented in Section 5; in Section 6, we present the results of empirical estimations, and the last section concludes.

2.2 Literature Review

2.2.1 Standard Portfolio Theory

Modern portfolio theory was applied by Pyle (1971) and Hart and Jaffe (1974) to investigate bank behaviour. This model treats a bank as a portfolio of assets and liabilities to be managed to maximise profits. The diversification of bank behaviour employing OBS items has been analysed from a standard portfolio view[4] (Stiroh and Rumble, 2006; Stiroh, 2006). A universal bank is engaged in both traditional activities, such as loans and deposits, and non-traditional activities, such as letter of credits, securities and fund management. Portfolio theory is shown as follows:

$$E(R_p) = E(R_{obs})q + E(R_{tra})(1-q) \tag{2-1}$$

$$\sigma_p^2 = \sigma_{obs}^2 q^2 + \sigma_{tra}^2 (1-q)^2 + \sigma_{obs}\sigma_{tra} \cdot \rho_{obstra} 2 \cdot q \cdot (1-q) \tag{2-2}$$

where,

$E(R_p)$ is the expected return of the portfolio including traditional banking behaviour and OBS.

$E(R_{obs})$ is the expected return of OBS.

$E(R_{tra})$ is the expected return of traditional banking activities.

q is the proportion of OBS to total activities, where $0 \le q \le 1$.

1-q is the proportion of traditional activities to total activities.

σ_p^2 is the variance of returns of the portfolio.

[4] In a financial institution, different traditional activities may interact in various ways with OBS activities, i.e., combining traditional activities with OBSs in a financial product; a standard portfolio view is one of the approaches to examining these two kinds of bank activity; however, it is suitable for this study as we attempt to investigate the effect of traditional activities and OBSs on bank performance in order to suggest the composition of an optimal portfolio for bank investment.

σ_{obs}^2 is the variance of returns from OBS.

σ_{obs} is the standard deviation of returns from OBS.

σ_{tra}^2 is the variance of returns from traditional activities.

σ_{tra} is the standard deviation of returns from traditional activities.

ρ_{obstra} is the correlation among the returns from OBS and traditional activities, where $-1 \le \rho_{obstra} \le 1$.

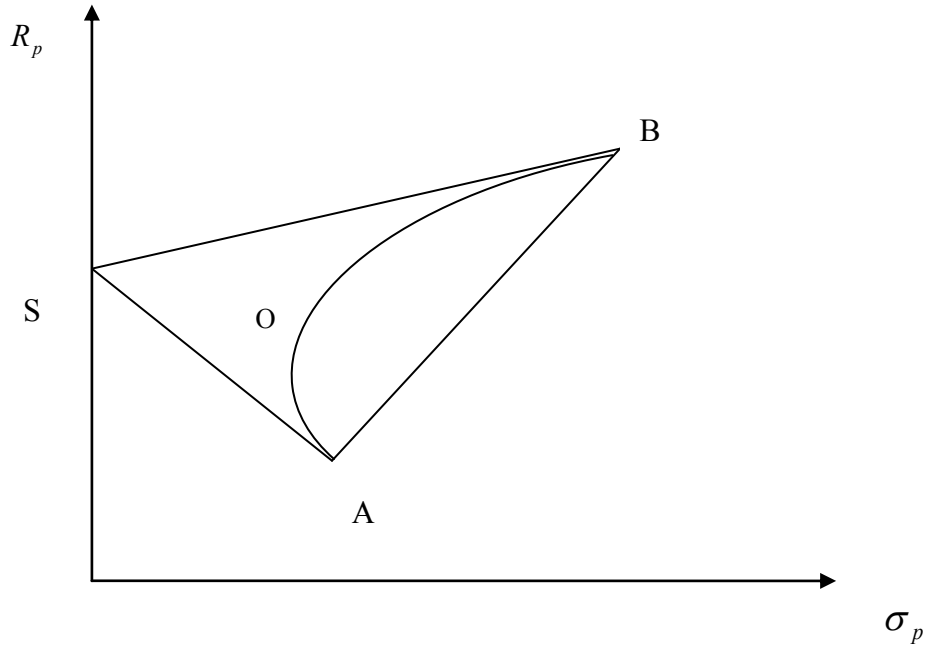
This portfolio approach shows a return-risk relationship in terms of different correlations of OBS with traditional activities[5]. The remainder of this section follows Sharpe *et al*. (1999, pp171-175). With the correlation coefficient +1 (perfect positive correlation), the standard deviation (risk) and the return of the portfolio are a linear combination. An increase in the level of the risk is associated with a higher level of the return of the portfolio. With the correlation coefficient 0, the risk and return are a non-linear combination. However, considering the proportion of OBS (q), we can minimise the risk level of the portfolio at $q = \frac{\sigma^2_{tra}}{\sigma^2_{tra} + \sigma^2_{obs}}$. With the correlation coefficient -1 (perfect negative correlation), the relationship between the risk and return is linear but segmented. The risk of the portfolio is equal to zero when the proportion of OBS is the ratio of the risk of traditional activities to the sum of the risks of traditional activities and OBS ($q = \frac{\sigma_{tra}}{\sigma_{tra} + \sigma_{obs}}$).

Figure 2-1 represents the relationship between the risk and return of the portfolio based on different correlations. The linear line AB represents the relationship given that the correlation

[5] The mathematic transformation is shown in Appendix 1.

is equal to +1. The curve AOB represents the relationship given that the correlation is equal to 0. The segmented linear line ASB represents the relationship given that the correlation is equal to -1. The area between the line AB and the line ASB is the limit within which all portfolios of banks must lie for a correlation if less than 1 and more than -1: this is called the efficient set. Based on this theory, Stiroh (2002, 2004 and 2006), Stiroh and Rumble (2006) and Chiorzazzo *et al*. (2008) investigated the effect of non-traditional activities on bank performance. Their empirical results are consistent with the implications of the efficient set theorem that a positive and significant correlation between traditional activities and non-traditional activities (cross-selling) indicates weak diversification revenue. However, they do not show an optimal portfolio selection considering the effects of both traditional activities and non-traditional activities. Therefore, we develop the portfolio framework by considering product diversification and traditional credit markets, in order to show an optimal bank portfolio both in the run-up to the recent crisis and during the crisis period.

Figure 2-1 Relationship between Expected Return and Risk in a portfolio



2.2.2 Portfolio Selection and Credit Rationing

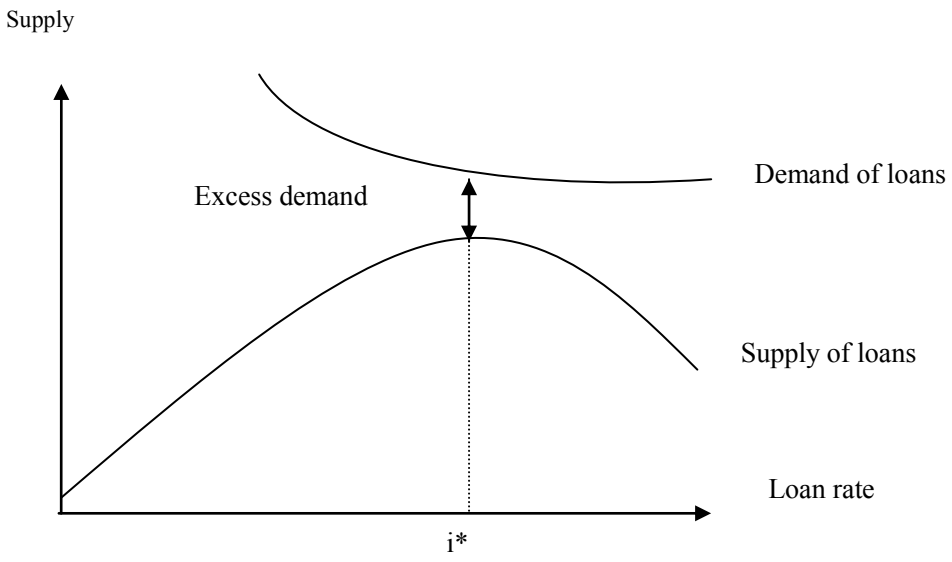
As regards the traditional credit market, banks allocate loans not only depending on the price, but also on a non-price device to ration credit, considering asymmetric information. Jaffee (1971, p15) shows a basic definition of credit rationing:

> *"Credit rationing is defined as the existence of an excess demand for commercial loans at the quoted commercial loan rate.*"

Freixas and Rochet (2008, p174-175) argue that, given credit rationing, the supply of loans depends on loan rates, and might not be a monotonic function of loan rates, owing to an adverse selection. A higher level of loan rates will increase bank returns below a threshold of loan rates, while it may reduce bank profits beyond the threshold, and higher loan rates may squeeze out borrowers with good credit as they are not willing to tolerate this higher interest rate; while risky borrowers accept that, because they have a lower probability of a successful project with higher return. Therefore, in this case, banks should decrease the supply of loans as shown in Figure 2-2: an equilibrium credit rationing occurs at the i* point. Beyond i*, banks are reluctant to lend even though borrowers are willing to pay a higher interest rate. In this case, banks might prefer to be involved in non-traditional activities, i.e., OBSs, to make profits, as shown in Figure 2-3, given a fixed capacity of bank activities. The curve in black shows OBSs before 2000 (checking from the right hand side to the left hand side in terms of the box of bank activities capacity). Initially, the involvement of OBSs generates a higher expected return, which is reduced as the proportion of OBSs increases. When OBSs are accompanied by a higher level of risk, the expected return sharply falls, so that A is the

equilibrium. The shift of OBSs in blue curve shows OBSs in post-2000[6]: we can find three cross points A', B and C[7], in terms of traditional activities and OBSs curves. The expected return at A' is higher than at C, therefore, banks should choose A' as an equilibrium, where the expected return with a higher proportion of OBSs is more than that pre-2000 (A), since Chiorazzo et al. (2008) suggest that economies of scale enable the long-run average costs of operating OBSs to be reduced. The green curve shows the shift of OBSs in 2007 and A'' is the equilibrium, leading to a lower expected return compared with previous periods partly due to the large proportion of OBSs associated with higher risk-taking at that time. This framework presents an increase in the proportion of OBSs in different sub-periods, considering credit rationing in traditional credit markets; however, the optimal amount of OBSs may depend on the risk level of bank activities in each sub-period.

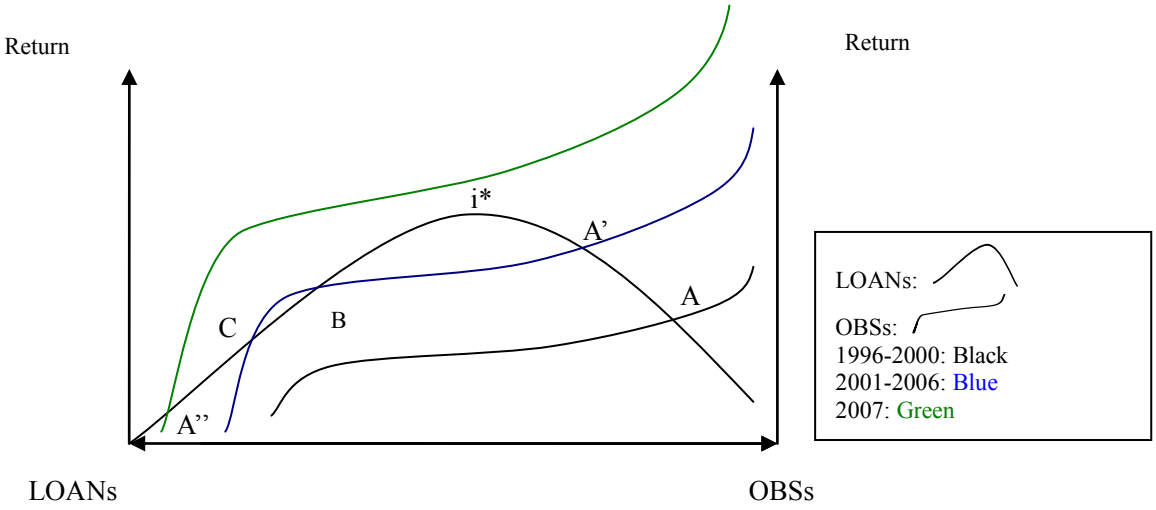
Figure 2-2 Credit Rationing



[6] Taking 2000 as a break in this framework is based on the change in non-traditional activities, as shown by the statistics on the size of the derivative market (http://www.bis.org/statistics/derstats.htm), suggesting that the size reduced from $18,718 billion to $15,665 billion during the period 1998-2000, and then, sharply increased until 2007, especially in 2007, the growth rate is nearly 50%.

[7] For A' and C, the moving trends of LHS and RHS are going to A' and C, which are stable equilibrium points; while for B, the moving trend is going outside, so B is not a stable equilibrium.

Figure 2-3 Expected Return and OBSs



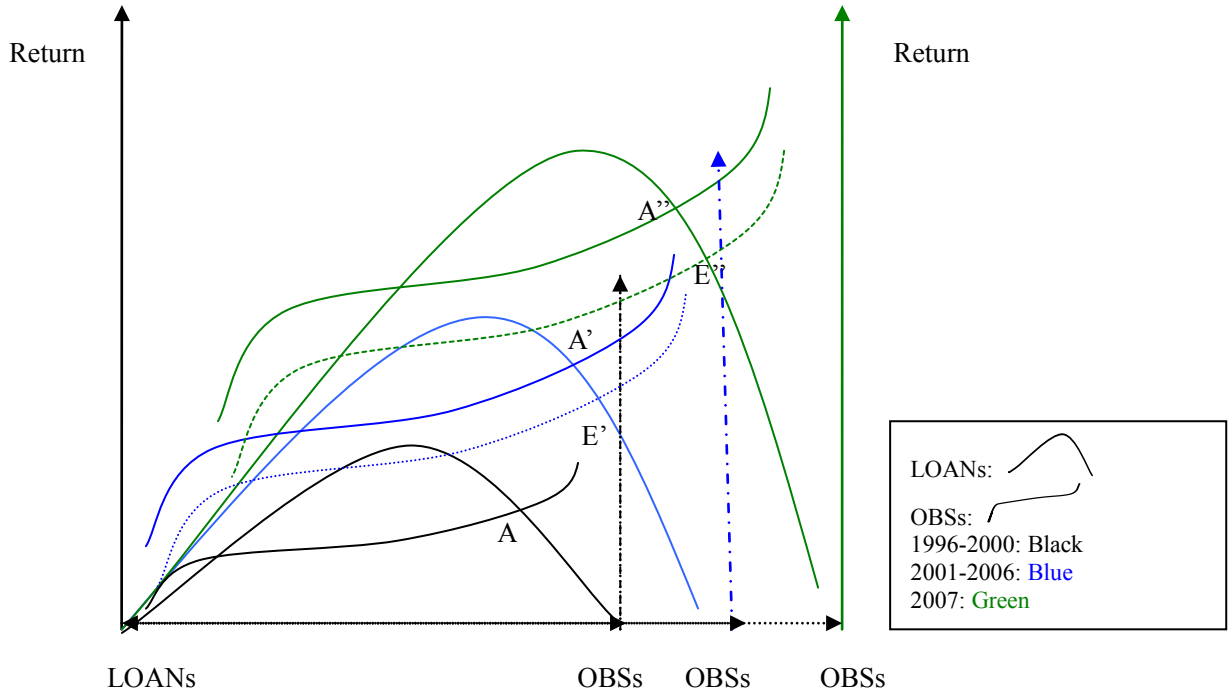
In addition, we introduce another framework showing that the capacity of bank activities including both OBSs and loans changes over three sub-periods. Taking the pre-2000 period as a basis, banks are involved in loans and OBSs, so that point A is the equilibrium indicated in the black curves, as shown in Figure 2-4. During the period 2001-2006, banks are able to enlarge the range of activities[8] so both traditional activities and OBSs are increased at the same proportion to generate a higher expected return (A') with an increase in the proportion of loans in equilibrium, as shown by the solid blue curves. In 2007, an increase in the capacity of bank activities leads to a higher expected return with an increase in the proportion of loans and A'' is the equilibrium, as shown by the green solid curves. Another case[9] is shown by the dotted curves post-2000 and 2007, showing that the shift of loans is more than OBSs, which leads to higher bank return with a higher proportion of loans in equilibrium at E' and E'' (E'<A', E''<A'') than in pre-2000. In general, this framework shows that the size of the box of

[8] The motivation for this is first, that the economies of scale can reduce the long run average costs of bank operations; second, the economies of scope can save costs of joint financial products; and third, given higher competition in financial markets, especially after 2000, banks have to engage in non-traditional activities in order to make profits to offset the losses from traditional bank activities.

[9] Canals (2006) suggests that in some circumstances, banks might consider switching costs from traditional activities to non-traditional activities, so they concentrate on traditional activities and make efforts to enlarge the size of that in order to benefit from the economies of scale.

bank capacity increases, so A (E) is the equilibrium at higher expected return with a higher proportion of loans[10], suggesting an optimal strategy for choosing bank activities in a bank portfolio based on two cases: one is that both activities change in the same proportion and the other is that the shift of loans is more than OBSs.

Figure 2-4 Expected Return of LOANs and OBSs (case 1 and case 2)



Regarding the growth of bank activities, there might be another case, as shown in Figure 2-5 that the shift of OBSs curve is more than loans, since OBSs as a financial innovation that enable bank behaviour to be more profitable. Banks can gain experience from the operation of OBSs pre-2000, as explained by "leaning-by-doing". However, stable equilibriums are indicated by A' (2001-2006) and A"(2007), with a higher proportion of OBSs and lower

[10] In Cases 1 and 2, since both the bank capacity and equilibriums (A'A" or E' E") move to the right, we cannot show whether the proportion of OBSs in a bank portfolio increases or not. However, we can still find a higher expected return in equilibrium accompanied by an increasing proportion of loans. This implies that in these two cases, as long as the proportion of loans increases, it leads to a higher expected return; while the proportion of OBSs does not matter.

proportion of loans in a bank portfolio, which show a reduction in the expected return compared with that in pre-2000, especially in 2007. This might suggest that inefficient risk management of new financial products associated with complicated bundling of obligations leads to higher risk-taking, which increases the volatilities of bank expected returns, based on the view of Deyoung and Roland (2001), Stiroh (2002, 2004) and Reinhart and Rogoff (2008). Moreover, it highlights that a fast growth strategy might be coupled with risky borrowers, which increases the risk level of bank activities. Thus, this framework[11] implies that an overcapacity problem, especially regarding OBSs, causes a decline in bank profits (Milne and Wood, 2003).

The fourth case[12] regarding the change of bank activities, as shown in Figure 2-6, is that the shift of the loan curve is down in 2007 owing to its lower profitability compared with OBSs and higher competition in the traditional credit market, which leads to a substitution in the bank portfolio away from loans towards more OBSs. Therefore, a stable equilibrium is shown by A" with a higher proportion of OBSs and lower proportion of loans, which is the cross point of the two green dotted curves: the expected return in equilibrium in 2007 is lower than that in previous sub-periods, as the overall portfolio risk might be higher. In this case, we also find that the expected return in 2007 is lower than that of Case 3, as shown in Figure 2-5[13], suggesting that a shift from traditional activities to OBSs generates higher volatilities of bank returns.

[11] In Figure 2-5, A' and A" are the equilibriums in 2001-2006 and 2007, respectively.
[12] The difference between Case 3 and Case 4 is indicated only in 2007.
[13] Comparing A" in Figure 2-6 with that in Figure 2-5, we find A" in Case 4 is lower than Case 3, as OBSs squeeze out traditional activities in a portfolio, leading to higher volatilities of bank returns.

Figure 2-5 The Expected Return of LOANs and OBSs (case 3)

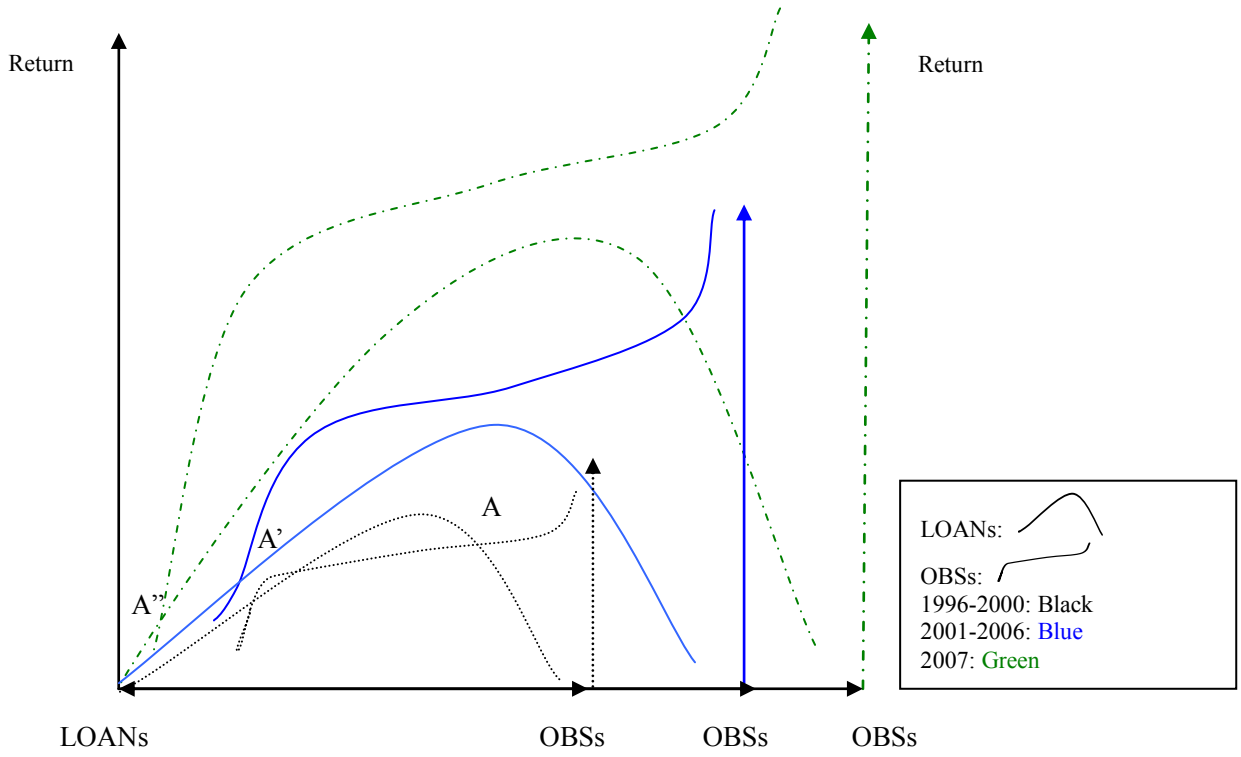
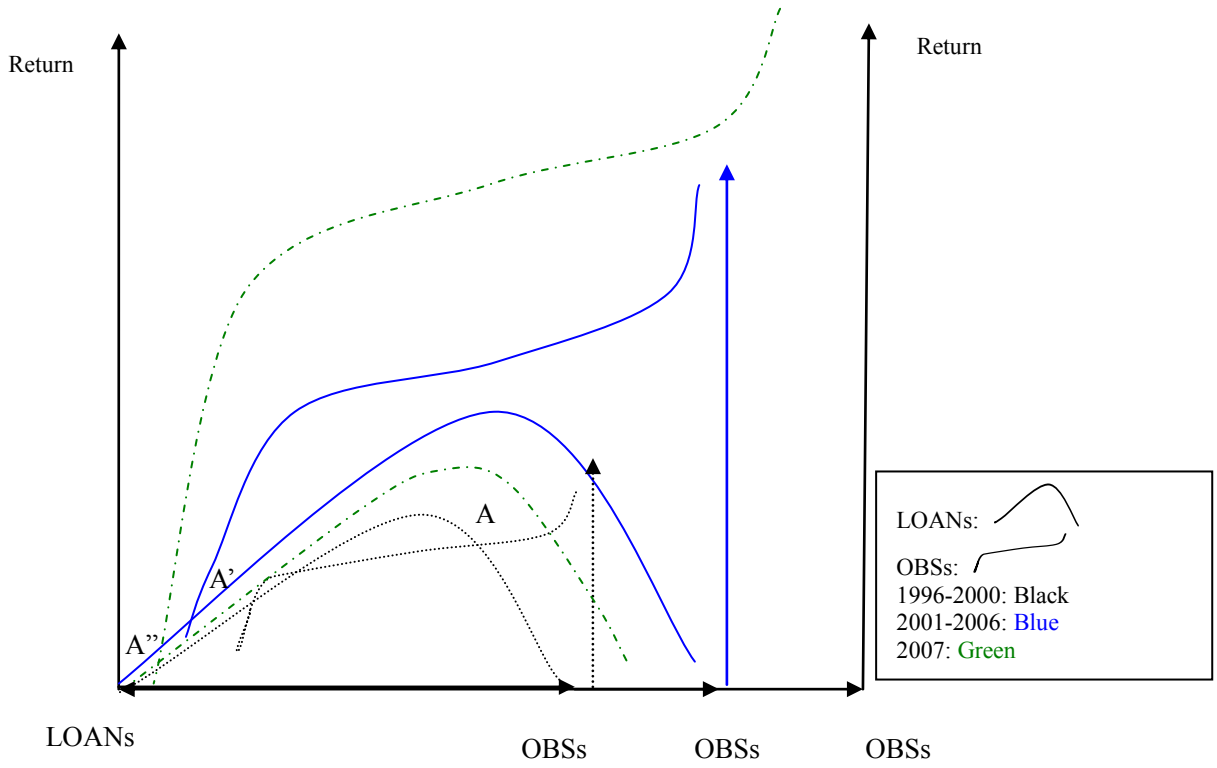


Figure 2-6 The Expected Return of LOANs and OBSs (case 4)



Basically, we present two frameworks considering credit rationing. The first is that, given a fixed capacity of bank activities, the shift in OBSs curve leads to the change in the OBSs proportion in a bank portfolio in determining bank expected returns in three sub-periods (1996-2000; 2001-2006 and 2007); the second is that we discuss the shift in the capacity of bank activities including OBSs and loans, leading to the change in the proportion of the composition of a bank portfolio in equilibrium in three sub-periods (1996-2000; 2001-2006 and 2007). In this framework, four cases are discussed above, taking the sub-period pre-2000 as a base. Figure 2-4 shows two cases: one is that both OBSs and loans shift increase in the same proportion owing to the economies of scale and benefits from TBTF, and the other is that the shift of loans is more than OBSs, considering switching costs and information costs transfer from traditional activities to non-traditional activities. Both cases lead to an increase in the expected return in equilibrium with a higher proportion of loans in post-2000 and 2007, no matter what the proportion of OBSs is; however, these expected returns are higher in Case 1 than in Case 2. Figure 2-5 shows that the shift in OBSs is more than loans due to their higher profitability and competition in traditional credit markets, leading to a decrease in expected returns with a higher proportion of OBSs and lower proportion of loans in a bank portfolio in equilibrium; Figure 2-6 presents the shift of loans being down in 2007, which leads to a lower expected return in equilibrium with a higher proportion of OBSs and lower proportion of loans in a portfolio in 2007 compared with that in Case 3 as shown in Figure 2-5. Table 2-1 shows a summary of the four cases in terms of OBSs and loans. Therefore, we empirically estimate the effects of changes in bank activities (OBSs and loans) on bank returns in the three sub-periods to support the scenarios presented in the frameworks.

Table 2-1 The Capacity of Bank Activities and Bank Return

	OBSs	LOANs	Return (R)	Figure
Case 1	increase	increase	increase (R1)	2-4
Case 2	increase	increase more than OBSs	increase (R2)	2-4
Case 3	increase more than LOANs	increase	decrease (R3)	2-5
Case 4	increase	decrease	decrease (R4)	2-6

Notes: R1>R2; R3>R4; The difference between Case 3 and 4 is indicated only in 2007; Since this study concentrates on the effect of product diversification, we do not discuss the case of a decline in non-traditional activities.

2.2.3 Portfolio Selection and Capital Regulation

The above discussion suggests the effects of changes in OBSs and loans on the selection of an optimal bank portfolio in three sub-periods. The huge losses from the recent financial crisis have already called into question the positive expectation of the impact of OBSs, which may require a policy response to recognise the distinction between traditional activities and OBSs; therefore, we attempt to show how to choose an optimal bank portfolio including OBSs and traditional activities, considering a risk-based capital regulation. According to Santos (1995), who constructed a theoretical model to explain the impact of capital requirement on bank asset composition, assuming that a bank behaves like a monopolist and is the unique external financial source for a firm, an increase in the capital requirement raises the losses of the bank's shareholders in the case of bankruptcy, which in turn forces banks to reduce assets associated with the higher risk level on behalf of shareholders' interests. This shows a theoretical interpretation of the issue that bank portfolio composition depends on its capital structure. Based on Furfine (2001), Mullings (2003) and Francis and Osborne (2009), we derive a theoretical model to compare the composition of bank portfolios in two cases: one is accompanied by a risk-weighted capital regulation, and the other is not, as shown in Appendix 2. This model suggests that a reduction in the marginal benefit of OBSs is more than that of loans in the presence of a risk-based capital requirement, which leads to a shift away from risky assets to safe assets in a portfolio. Therefore, in this respect, we may show the

composition of bank portfolios, considering the effect of capital regulation on bank performance. It is worth noting that we pay more attention to the return per unit of risk rather than the absolute level of risks or total returns, so the Sharpe Ratio (SR)[14], as a measurement of the return per unit risk, is considered.

The Sharpe Ratio is defined as:

$$SR = \frac{E(R)}{\sigma(R)} \tag{2-3}$$

where,

E(R) is the expected excessive return.

$\sigma(R)$ is the standard deviation of return (risk).

Following the implications of standard portfolio theory,

$$\frac{d(SR_{Tra})}{dq} > 0; \quad \frac{d(SR_{obs})}{dq} < 0 \tag{2-4}$$

where,

SR_{Tra} is the Sharpe Ratio of traditional activities.

SR_{obs} is the Sharpe Ratio of OBSs.

q is the proportion of OBSs to total operating activities (where $0 \le q \le 1$).

According to the extent of capital requirement in determining the composition of the portfolio,

[14] In this study, the Sharpe Ratio is related to a portfolio or particular bank activities, such as traditional and non-traditional activities in a bank. The SR used here is not a traditional Sharpe Ratio, therefore, we call it the "Internal Sharpe Ratio". For simplicity, we still use Sharpe Ratio in the text.

there are two cases to be discussed.

Case 1:

We assume that the extent of capital requirement (*CR*) on OBSs is the same as traditional activities. *CR* has an impact on the Sharpe ratio and is a function of the composition of a portfolio and interest rates, as suggested in our theoretical work[15]. To simplify matters, we do not show a specific function of *CR*, since in this case they are the same in terms of OBSs and traditional activities. Therefore, recalling Eq.2-4, we can define two functions of SR of the traditional activities and OBSs, respectively.

$$SR_{Tra} = kq \quad (k>0) \tag{2-5}$$

$$SR_{obs} = k(1-q) \,(k>0) \tag{2-6}$$

where,

k is used to reflect CR and is a slope of SR_{Tra} function.

-k is a slope of SR_{obs} function.

In equilibrium, the value of SR_{Tra} should be equal to SR_{obs}, in other words, Eq. 2-5 is equal to Eq. 2-6, as shown in Figure 2-7.

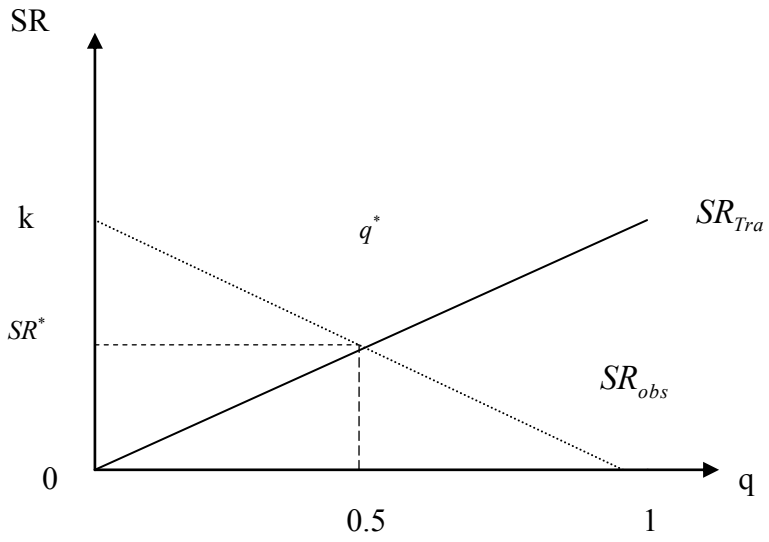
$$kq = (1-q)k \tag{2-7}$$

$$q^* = 0.5$$

[15] Capital requirement in Case 1 is defined as $K_t = \frac{1}{1-r_t^d}[K_{t-1} + r_t^l L_t + r_t^s S_t + r_t^o OBS_t - r_t^d L_t - r_t^d S_t - r_t^d OBS_t]$, see Appendix 2.

The optimal value of the proportion invested in OBSs (q^*) is 0.5 in Case 1. Figure 2-7 explicitly describes the relationship between *SR* and *q* to identify the value of *q* in equilibrium with the same extent of capital requirement for bank activities.

Figure 2-7 Relationship between SR and q (case 1)



Case 2:

In this case, we consider a risk-based capital requirement imposed on different bank activities. Assume that α is the risk weight of traditional activities and β is the risk weight of OBSs, $\beta+\alpha=1$, $\beta>\alpha>0$ and $1>\beta>0.5$. Two functions of *SR* are defined as below:

$$SR_{tra}=\frac{K}{(1-\beta)(1-q)}\text{q} \tag{2-8}$$

$$SR_{obs}=\frac{K}{\beta q}(1\text{-q}) \tag{2-9}$$

where,

K is the capital requirement without considering the different risk weights of bank activities.

The right-hand-side of Eq. 2-8 $(\frac{K}{(1-\beta)(1-q)})$[16] shows a risk-based capital requirement for traditional activities. As $SR_{tra}' = \frac{K}{(1-\beta)}(1-q)^{-2} > 0$ and $SR_{tra}'' = \frac{2K}{(1-\beta)}(1-q)^{-3} > 0$, SR_{tra} is an increasing function and convex with $0 \le q < 1$.

The right-hand-side of Eq. 2-9 $(\frac{K}{\beta q})$ shows a risk-based capital requirement for OBSs. As $SR_{obs}' = -\frac{K}{\beta}q^{-2} < 0$ and $SR_{obs}'' = \frac{2K}{\beta}q^{-3} > 0$, SR_{obs} is a decreasing function and convex with $0 < q \le 1$.

As suggested in Case 1, the optimal value of q occurs given that Eq.2-8 is equal to Eq.2-9, thus,

$$\frac{K}{(1-\beta)(1-q)}q = \frac{K}{\beta q}(1-q) \tag{2-10}$$

$$q^* = \frac{\beta - 1 + \sqrt{\beta - \beta^2}}{2\beta - 1} \quad (1 > \beta > 0.5) \tag{2-11}$$

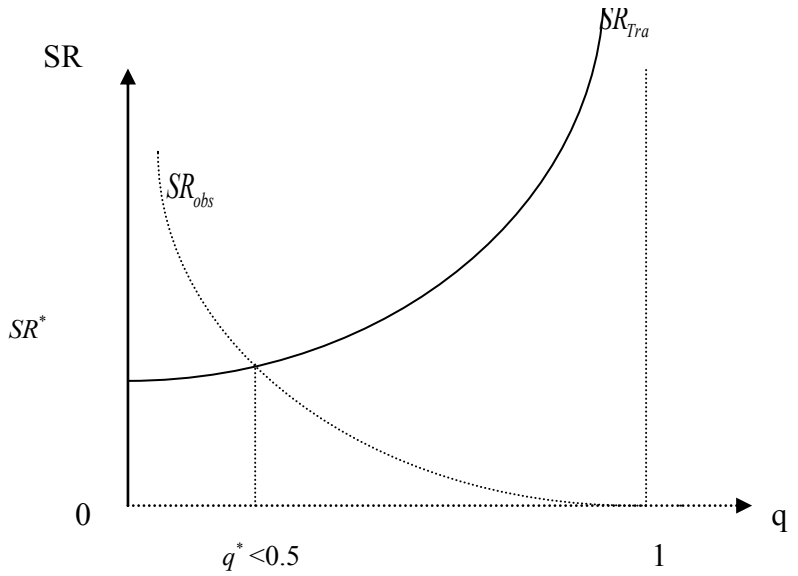
As $1 > \beta > 0.5$, q^* is a decreasing function and is strictly between 0 and 0.5 ($0 < q^* < 0.5$). The mathematic transformation is shown in Appendix 3.

Figure 2-8 gives an optimal strategy for the composition of a portfolio in terms of Case 2. The SR functions are non-linear according to Eqs. 2-8 and 2-9. The value of q in equilibrium is lower than that of Case 1. This implies that a risk-based capital requirement forces banks to

[16] For the functions of capital requirement in Case 2 please see Appendix 2.

shift away from OBSs to traditional activities in portfolios and highlights the substitute effect between OBSs and traditional activities.

Figure 2-8 Relationship between SR and q (case 2)



Based on this theoretical framework, under the same capital requirements for traditional activities and OBSs, banks should choose half-and-half between traditional activities and OBSs in equilibrium; however, given a risk-based capital requirement, banks prefer holding fewer OBSs than traditional behaviour in order to minimise the regulatory costs. This provides an intuition that traditional activities cannot be completely replaced by OBSs in a portfolio, even though OBSs are associated with a higher level return. Considering a risk-based capital regulation, through empirical work, we expect that an increase in OBSs leads to a lower level bank return, as banks have to pay a higher level of capital regulatory costs when choosing more OBSs; while the risk-based capital regulation may have no (less) impact on traditional activities, i.e., loans. As this theoretical work considers the effect of bank activities on SR, the risk-adjusted bank performance should be used in the estimation.

2.2.4 Empirical Evidence

The previous studies on OBSs include three aspects: the relationship between OBSs and bank risk, the factors facilitating OBSs, and the effect of OBSs on bank performance[17]. However, our study contributes to the third stream, that is, an investigation into the effect of OBSs on bank performance, further to draw a conclusion about an optimal bank portfolio selection; therefore, we would like to present more detailed review in this perspective.

There have been several evaluations on the effect of increasing non-traditional activities on bank performance; however, the results of the effect of non-traditional activities vary. On one hand, the new lines of bank activity generate stable profits and reduce regulatory costs, and at the same time, diversify bank risk, as suggested by Chiorazzo *et al*. (2008). Using data on Italian banks, they investigated the effect of diversification of bank activities on risk-adjusted returns. They find a positive relationship between them for large sized banks. Large banks have advantages (advanced technologies and efficient management) in operating activities, which in turn reduces marginal costs and increases risk-adjusted returns. Baele *et al*. (2007) indicate that functional diversification improves the trade-off between return and risk by taking European banks as a sample from 1989 to 2004. A higher level of non-interest income share increases a bank's franchise value. Davis and Tuori (2000) find that non-interest income has been enhanced to offset losses from traditional banking activities in the EU financial market.

Nevertheless, banks may increase the volatilities of their returns by using non-traditional, due to switching costs, higher financial leverage and higher operational leverage, as summarised

[17] As my work contributes to the third stream of OBSs study, we present a more detailed review of the effect of OBSs on bank performance; however, the review regarding the other two streams is summarised in Table 2-1.

by DeYoung and Roland (2001). As suggested by Calmes and Theoret (2010), a significant higher volatility of bank returns has been found when increasing OBSs in the Canadian banking sector. Therefore, the results suggest that better pricing on risk-taking of OBSs should be emphasised. From a portfolio view, Stiroh (2006) indicates that an increase in non-traditional activities yields fewer returns, while it generates a higher level of risk-taking, considering the US banking sector. Stiroh and Rumble (2006) find that diversification increases bank returns, but this is offset by exposure to non-traditional activities. Similarly, Stiroh (2004) suggests that a higher level of diversification has a negative impact on bank performance, based on community banks in the US. The volatility of banking returns may result from less experience of operating non-traditional activities. Stiroh (2002), considering the US banking industry from 1984 to 2001, suggests that a diversification of banking activities increases the volatilities of banking profits. Excessive reliance on non-traditional activities generates a higher risk level and reduces bank profits. Deyoung and Roland (2001) show that a higher volatility of bank returns appeared in US commercial banks from 1988 to 1995. Regarding non-traditional activities, there is a less stable bank-customer relationship compared with that of traditional bank activities. Most previous studies use non-interest income share as a measure of the employment of non-traditional activities based on a standard portfolio view (see Eqs 1 and 2 in Appendix 1); however, they do not show an optimal portfolio selection combining the effects of OBSs and loans. In addition, although some previous papers point out the importance of regulation in determining bank performance, they do not provide empirical analyses on the effect of bank regulation on bank portfolio selection, especially considering the recent financial crisis. Therefore, this chapter aims to present an optimal bank portfolio selection to support the scenario described in the frameworks as shown in Figures 2-3, 2-4, 2-5 and 2-6, and also show an optimal bank portfolio considering the

effect of risk-based capital regulation, both in the run-up to the recent crisis and the crisis period. Table 2-2 presents a summary of the literature review.

From the theoretical and empirical implications, we can obtain some important variables to be used in this study. First, Calmes and Theoret (2010), Baele et al. (2007), Stiroh and Rumble (2006) and Stiroh (2004) suggest that non-interest income can reflect the effect of bank diversification, as it is mainly generated from managed securitised assets, guarantees, committed credit lines and other non-traditional bank behaviour. Thus, the ratio of non-interest income to total operating income as a proxy of the investment in non-traditional activities can be used in this study. According to the standard portfolio theory mentioned above, if a negative effect of non-interest income share can be found, this suggests that a positive correlation between interest income and non-interest income reduces diversified benefits; while a positive effect suggests diversified bank gains. Second, Hauston and Stiroh (2006), Calmes and Theoret (2010) and Delis and Kouretas (2011) point out that non-traditional activities are more sensitive to aggregate shocks (macroeconomic shocks) than traditional bank activities, therefore, in this study, we investigate the effect of macro-shocks measured by GDP growth rate and interbank rate (market risk) on bank profitability. Third, based on the frameworks related to the effect of OBSs and loans on bank expected return introduced before, we attempt to use OBSs and loans as two measures of the composition of a bank portfolio in the estimation. Fourth, based on the theoretical model related to the effect of capital regulation, in this study, capital regulation should be considered.

Table 2-2 A Summay of Literature Review

(1) The relationship between OBS and bank risk						
Author	Year	Sample countries	Sample time	Dependent variable	Explanatory variables	Main results
Hassan, Karels and Peterson	1993	US Bank-level data	1984-1988	Bank asset risks measured by deposit insurance premium, equity variance and risk premia (default risk) of subordinated debts, respectively	(1) OBSs: commitments, swaps, commercial letters of credit, standby letters of credit, securities and participations (2) Ratio of liabilities over total assets (3) Portfolio diversification (4) Ratio of loan loss reserve to total assets (5) Bank assets (6) Ratio of net positions (total market rate assets minus market rate liabilities) to total assets	(1) OBS items reduce the asset risk, since market participants price OBSs as risk-reducing by considering market discipline of OBSs.
Hassan and Sackley	1994	US Bank-level data	1984-1988	Bank asset risks measured by equity variance and risk premia (default risk) of subordinated debts, respectively	(1) OBSs: loan commitments deflated by total assets (2) Ratio of liabilities over total assets (3) Portfolio diversification (4) Ratio of loan loss reserves to total assets (5) Bank assets (6) Ratio of net positions to total assets	(1) Loan commitments reduce bank risk (2) Loan commitments contribute to the overall diversification of bank portfolio.
Hassan	1993	US Bank-level data	1984-1988	Bank asset risk measured by equity variance	(1) OBSs: commitments, swaps, commercial letters of credit, standby letters of credit, securities and participations (2) Ratio of liabilities over total assets (3) Portfolio diversification (4) Ratio of loan loss reserves to total assets (5) Bank assets (6) Ratio of net positions to total assets (7) Ratio of cash dividends to net income	(1) OBS items reduce the total risk of portfolio. (2) OBS items have an insignificant impact on the systemic risk of the portfolio.
Lepetit, Nys, Rons and Tarazi	2008 a	European countries Bank-level data and macro-level data	1996-2002	Risk measures (the standard deviation of the return on average assets, the standard deviation of the return on average equity and	(1) Noninterest income ratio (2) Ratio of net commission income to net operating income (3) Ratio of net trading income to net operating income (4) Bank size	(1) Generally, banks with higher non-traditional activities are indicative of higher risk-taking (2) Small banks having trading activities are associated with lower risk-taking.

				loan loss provision ratio) and Insolvency risk measures (z-score and distance to default)	(5) ROA and ROE (6) Loan ratio (7) Personal expenses (8) Growth rate of total assets (9) Equity ratio	
(2) The factors facilitating OBS						
Jagtiani, Nathan and Sick	1994	US Bank-level data	1988-1990	Earning assets	(1) Deposits (2) OBSs: swaps and loan securitizations (3) Price of capital	(1) Capital requirement is a main factor facilitating OBSs. (2) OBSs cannot reduce bank operational costs
Pavel and Phillis	1987	US Bank-level data	1983-1985	Ratio of loans sold to total assets	(1) Regulatory taxes (2) Diversification of loans (3) Non-interest expenses to total assets (4) Growth rate of loans (5) Loan charge-off (6) Asset size	(1) Regulatory cost is the reason for banks engaging in OBSs (swaps and loan securitizations). (2) Size effect and Non-interest expenses also contribute to OBSs (swaps and loan securitizations).
Benveniste and Berger	1987	US Bank-level data	December, 1985	The probability of issuing SLCs (Stand letter of credit).	(1) Capital to total exposure ratio (2) Ratio of the sum of equity capital and loan loss reserve to the sum of SLCs and TA (Total Assets) (3) Probability of a poor CAMEL rating (4) Ratio of operating costs to the sum of SLCs and TA (5) Dummies of whether a bank is in violation of its capital adequacy (6) Dummies of whether a bank has international deposits.	(1) Riskier banks prefer to be involved in the securitization. (2) Higher operation costs and international banking behaviour also enable banks to increase the OBSs (standby letter of credit and guarantees).
Boyds and Gertler	1994	US Bank-level data	1983-1991	Non-econometric methods are Basel credit equivalents and non-interest income capitalization credit equivalents, respectively. The former provides a	N.A.	(1) Competition with non-financial industries leads to an increasing of OBS (securitizations). (2) A fast increase in OBS (securitizations) is not good for banks.

				measure of OBSs in units of on-balance-sheet activities. The latter is used to estimate OBSs by non-interest income relative to net interest income.		
Cheng and Fung	2004	Hong Kong Bank-level data	1990-2000	(1) Contingent liabilities (2) Exchange rate contracts (3) Interest rate contracts	(1) Lagged variables of dependent variables (2) Total assets (3) Return on equity (4) Provision for bad debts (5) Interest income (6) Herfindahl-Hirschman index (7) Market share based on NII (Non-interest income)	(1) The positive effect of market competition and information complementarity on the diffusion of OBSs is found. (2) Little evidence of the size effect is found on OBSs.
Sinha	2006	India Bank-level data	1996-1997, 2000-2001	Total OBS items	(1) Capital to risk weighted asset ratio (2) Net non- performing assets (3) Operating profits (4) Working fund (5) Total assets (6) Loan loss provision	(1) OBSs are negatively linked with non- performing assets but positively related to the operating profits. (2) Negative relationship between OBSs and loan loss provision (3) Negative relationship between OBSs and the size effect
Nachane and Ghonh	2007	India Bank-level data and macro-level data	1996-2004	Total OBS items	(1) Total assets (2) Capital adequacy ratio (3) Ratio of non-performing loans to net advances (4) Interest spread (5) GDP growth rate	(1) Positive relationship between capital adequacy ratio and OBSs (2) Positive relationship between non-performing loan ratio and OBSs (3) Negative relationship between spread and OBSs
Casu and Girardone	2005	European countries	N.A.	Non -econometric method: Malmquist total factor productivity	N.A.	(1) Employing OBSs is significant in banking output over time. (2) OBSs play an important role in determining banking productivity.
(3) The effect of OBS on banking performance						
Baele,	2007	EU15	1989-2004	(1) Franchise value	(1) Non-interest income share (NII)	(1) OBSs are positively related to the

Jonghe and Vennet		Bank-level data		(2)Variance of revenue	(2) NII squared (3) Loans to total assets (Loan) (4) Loan squared (5) Revenue diversity (6) Asset diversity (7) Equity ratio (8) Equity squared (9) Cost to income (10) Bank assets	franchise value. (2) OBSs increase systemic risk. (3) OBSs reduce idiosyncratic risk.
Demsetz and Strahan	1997	US Bank-level data	1980-1993	(1) Market return (2) Variance of market return	(1) Bank assets (2) Loans to total assets (3) Deposits to total assets (4) Total OBS items (5) NII share (6) Book value of capital to asset (7) Turnover	(1) A large bank is better diversified than a small bank. (2) OBSs do not reduce risk-taking. (3) A diversification encourages banks to be consolidated in order to pursue higher profits.
Davis and Tuori	2000	EU countries Bank-level data	1979-1995	(1) Ratio of non-interest income to total assets (2) Ratio of non-interest income to average assets	(1) Total assets (2) Ratio of total costs to total income (3) Ratio of return on average equity (4) Ratio of interest income to average asset	(1) Large bank is able to obtain higher non-interest incomes. (2) The higher cost to income ratio leads to an increasing non- interest income. (3) Little evidence on the issue that higher non-interest income could offset the losses from interest income.
Calmes and Theoret	2010	Canada Bank-level data	1988-2007	(1) Return on asset (ROA) (2) Return on equity (ROE)	(1) NII share (2) Loan loss provision (3) One lag of dependent variables	(1) OBSs do not yield benefits. (2) The risk premium is associated with OBSs between 1988 and 1996. (3) OBSs do not negatively impact the bank return during 1997 to 2007.
Chiorazzo, Milani and Salvini	2008	Italy Bank-level data	1993-2003	(1) Sharpe Ratio for ROA (2) Sharpe Ratio for ROE	(1) Bank assets (2) Non-performing loan ratio (3) Equity ratio (4) Loan ratio (5) Net interest income (6) Non-interest income ratio	(1) A positive relationship between product diversification and risk-adjusted return in large banks (2) The amount of non-interest income is more important than the source of non-interest income in

					(7) Share of net trading income to operating income (8) Share of net commission income to operating income (9) Proxies of diversification	determining the level of risk-adjusted return.
Stiroh	2006	US Bank-level data	1997-2004	(1) Market return (2) Variance of market return (3) Market beta	(1) NII share (2) Bank assets (3) Equity to total assets	(1) NII does not yield a higher equity return. (2) NII generates a higher level of risk-taking.
Stiroh and Rumble	2006	US Bank-level data	1997-2002	(1) Return on asset (2) Return on equity	(1) NII share (2) Diversification of activities (3) Bank assets (4) Equity to total assets (5) Loan to total assets (6) Asset growth (7) Asset growth squared	(1) The benefits from diversification are offset by the exposure to OBSs. (2) NII generates more volatilities of bank profitability than traditional bank activities.
Stiroh	2004	US Bank-level data	1984-2000	(1) Mean of ROA (2) Variance of ROA (3) Mean of ROE (4) Variance of ROE (5) Z-Score (6)Risk-adjusted banking performance	(1) NII share (2) Diversification of activities (3) Bank assets (4) Equity to total assets (5) Loan to total assets (6) Asset growth (7) Asset growth squared (8) Average age of banks	(1) NII decreases the risk-adjusted return. (2) The traditional bank activities (loans) also reduce the return.
Stiroh	2002	US Bank-level data	1984-2001	(1) Net income growth (2) ROE (3) Z-Score (4) NII revenue (5) Interest income	(1) Bank assets (2) Equity to total assets (3) Asset growth (4) NII share (5) NII share squared (6) Total OBS items (7) Four lags of dependent variables	(1) OBSs yield a higher volatility than traditional banking activities. (2) Relying on OBSs increases a higher risk level and reduces the risk-adjusted return. (3) The close correlation between interest income and non-interest income is suggested.
DeYoung and Roland	2001	US Bank-level data	1988-1995	The degree of total leverage	(1) Deposit revenue share (2) Loan revenue share (3) Investment revenue share (4) Fee-based revenue share	(1) OBSs enhance a higher volatility of revenues. (2) OBSs increase the degree of total leverage.

					(5) Trading revenue share (6) Total revenue (7) Total revenue squared	

2.3 Data Selection

In this study, we use both bank-level data from Bureau van Dijk Bankscope[18] and country-level data from Datastream and international financial statistics (International Monetary Fund, IMF). The sample period is from 1996 to 2007[19] owing to data availability in Bankscope. We consider the banks with OBSs data disclosure during the study period. To avoid abnormal values in the sample, we drop eight banks that were beyond the interval of the 1st and 99th percentiles in terms of bank performance, as measured by the ratio of net income to total assets. Therefore, we obtain the un-balanced panel data on 359 banks in seven developed countries, of which 50 are from Austria, 20 are from Belgium, 27 are from Denmark, 92 are from France, 48 are from Germany, 31 are from the UK and 91 are from the US.

2.4 Model Specification and Variables

2.4.1 Basic Empirical Model

The basic empirical work is used to identify the scenario described in the framework as shown in Figure 2-3 in three sub-periods (1996-2000, 2001-2006 and 2007). In this work, considering credit rationing, banks are inclined to engage in more OBSs in order to make profits. However, the optimal amount of OBSs holding varies depending on the risk level of bank activities in different periods. Thus, we attempt to investigate the effect of OBSs on bank profitability in the three sub-periods. We expect that a positive effect of OBSs should be found in the earlier sub-periods; while a negative effect should be found in 2007. In addition, from the summary of previous empirical research, researchers have already identified the significant effect of non-interest income ratio (NII) as a measure of bank diversification on

[18] The estimated sample in this thesis is commercial banks.
[19] I downloaded data for Chapter 1 in 2008, and at that moment, the maximum period of data in Bankscope is from 1996 to 2007.

bank performance, although this effect is either positive or negative; as a result, non-interest income ratio should be included in this estimation. Based on standard portfolio theory, a negative effect of non-interest incomes ratio suggests a positive correlation between traditional activities and OBSs and a weak diversification gain. Moreover, loan loss provision (LLP) as a proxy of default risk from traditional activities, i.e., loans, should be used. In addition, regarding the impact of macro-shocks, we take the GDP growth rate into consideration, and interbank rate (*Interb*) as a proxy of market risk is also used. Therefore, the empirical model is shown as:

$$\text{Bank Profitability} = (c, OBSs, NIIs, LLP, GDP, Interb) \tag{2-12}$$

In order to present the evidence of splitting estimated period into three sub-periods following the theoretical work as shown in Figure 2-3, we use the Chow test (1960). Based on this study, to test whether there are two breaks (1996-2000, 2001-2006 and 2007) within the sample period, we estimate a combined equation shown as follows:

$$Y = a + \vec{b}\vec{X} + cd_2 + \vec{e}d_2\vec{X} + gd_3 + \vec{f}d_3\vec{X} + \mu$$

where,

Y is a dependent variable (return on assets) as a measure of bank performance.

a is a vector of constant.

$\vec{X}$ is a vector of 5 explanatory variables (see Eq.2-12) in the whole period from 1996 to 2007.

$\vec{b}$ is a vector of 5 coefficients.

d_2 is a dummy variable and is defined as 1 between 2001 and 2006, 0 otherwise.

d_3 is a dummy variable and is defined as 1 in 2007, 0 otherwise.

$\vec{e}$ is a vector of the coefficients of 5 interaction variables in terms of the sub-period 2001-2006.

$\vec{f}$ is a vector of the coefficients of 5 interaction variables in the sub-period 2007.

μ is an error term.

c and g are the coefficients of dummy variables.

The null hypothesis is that the parameters (c, g, $\vec{e}$ and $\vec{f}$) are jointly equal to 0, indicating that there is no break within the whole sample period; the alternative hypothesis suggests that there are two breaks, giving 1996-2000, 2001-2006 and 2007. We can construct a *F*-statistic with the degree of freedom (K_1, N-K). K_1 is the number of tested coefficients (c, g, $\vec{e}$ and $\vec{f}$), *N* is the number of total observations and *K* is the number of independent variables in the combined equation. By using a Wald test, F (12, 3441)=17.47, which is greater than the critical value (1.75) at the 5% significant level, so we can reject the null hypothesis and confirm that there is the difference between these three sub-periods.

Therefore, recalling Eq.2-12, the empirical models with three sub-periods (1996-2000, 2001-2006 and 2007) in terms of *NIIs, OBSs,* and *LLPr*, respectively, are indicated.

$$Y_{i,j,t} = c + \theta_1 NIIs_{i,j,t1} + \theta_2 NIIs_{i,j,t2} + \theta_3 NIIs_{i,j,t3} + \alpha_2 OBSs_{i,j,t} + \alpha_3 LLPr_{i,j,t} + \beta_1 GDP_{j,t} + \beta_2 Interb_{j,t} + \kappa_t + \lambda_i + \varepsilon_{i,j,t} \quad (\text{Ⅰ})$$

$$Y_{i,j,t} = c + \theta_1 OBSs_{i,j,t1} + \theta_2 OBSs_{i,j,t2} + \theta_3 OBSs_{i,j,t3} + a_2 NIIs_{i,j,t} + a_3 LLPr_{i,j,t} + b_1 GDP_{j,t} + b_2 Interb_{j,t} + k_t + \lambda_i + \varepsilon_{i,j,t} \quad (\text{Ⅱ})$$

$$Y_{i,j,t} = c + \theta_1 LLPr_{i,j,t1} + \theta_2 LLPr_{i,j,t2} + \theta_3 LLPr_{i,j,t3} + a_2 NIIs_{i,j,t} + a_3 OBSs_{i,j,t} + b_1 GDP_{j,t} + b_2 Interb_{j,t} + k_t + \lambda_i + \varepsilon_{i,j,t} \quad (Ⅲ)$$

where,

Y=NI/TA is a measure of bank performance, bank profitability is measured by the ratio of net income (*NI*) divided by total assets (*TA*) and it is in the form of a natural log.

$OBSs = OBS / TA$, based on the framework introduced before as shown in Figure 2-3, considering credit rationing, banks restrict the supply of loans beyond a threshold of interest rate, so banks are involved in OBSs in order to make profits. Since the 1990s, the amount of OBS assets has been greater than that of on-balance-sheet assets in the US (Kaufman, 1992, p479). The development of OBS items has transferred the intermediary role of banks to the role of risk management, which is accepted by the modern banking industry (Heffernan, 1996, p28). Thus, this offers us a chance to use OBSs[20] as a measure of bank diversification. Large involvement in OBS items was initially seen as a source of higher return, while benefits from OBS assets might be offset by exposure to OBSs, especially when taking the recent financial crisis into consideration.

$NIIs = NII / TOI$, a proxy of bank diversification is considered as another main independent variable. Based on the standard portfolio theory, the effect of diversification on bank performance depends on the correlation between interest income and non-interest income. According to Stiroh (2006), this can be measured by the ratio of net non-interest income (*NIIs*) to total operating revenue (*TOI*): *NII* is defined as the sum of gains (losses) on trading,

[20] OBSs include Managed Securitised Assets Reported off-balance sheet, Other off-balance sheet exposure to securitisations, Guarantees, Acceptances and documentary credits reported off-balance sheet, Committed Credit Lines and Other Contingent Liabilities based on the definition of Bankscope.

derivatives and other securities, fees and commissions, and other non-interest income minus the sum of operating expenses; *TOI* is defined as the sum of net interest income and net non-interest income.

$LLPr = LLP/TA$, regarding the exposure of traditional bank behaviour, we use the ratio of loan loss provisions (*LLP*) to total assets. The ratio of LLP (*LLPr*) has been employed in numerous studies (see Gonzales and Hermosillo, 1996; Demirgüç-Kunt and Huizinga, 1998; Nys, 2003; Fonseca and González, 2007; Baele et al., 2007; Chen, 2007; Calmès and Théoret, 2010) to measure the credit risk of banks. In this study, we use the ratio of loan loss provision, which shows the effect of traditional activities, i.e., loans, associated with credit risk, on bank performance. The higher level risk of loans requires an increasing amount of loan loss provision, which is used as a buffer against potential risk-taking. Thus, a large LLP has a negative impact on bank performance.

$GDP = (GDP - GDP_{t-1}) / GDP_{t-1}$, The value of the GDP growth rate in the year *t* is calculated by dividing the value in the year *t* minus the value in the year *t-1* by the value in the year *t-1*. Data are chosen from international financial statistics (IMF). GDP as an indicator of the economy describes the relationship between bank performance and the development of the economy. A close link between these has been identified in many previous papers (see Bikker and Hu, 2002; Stiroh, 2004b; Gerlach et al., 2004; Fonseca and González, 2007). The GDP growth rate reflects a change in the macro-economy, which determines the environment of bank diversification. The rapid development of the economy provides a chance for banks to make profits from diversification and lower the risk level.

Interb is the interbank rate[21] (three-month) as an indicator of the money market. As suggested in Panetta et al. (2004), the short-term money market rate reflects the marginal lending costs. A higher level of interbank rates increases lending costs, which may absorb borrowers with bad credit and increase the risk level (an adverse selection). The money market rate is also a proxy of market risk, whose significant volatilities have an impact on bank profits and capital holdings. Thus, a higher interbank rate is associated with large expenses and lower benefits.

$\theta_1 NIIs, \theta_1 OBSs\ and \theta_1 LL\Pr$ are interaction variables in terms of non-interest income share, off-balance-sheet share and loan loss provision ratio, respectively. This is equal to the original value of variables for the period 1996-2000, and 0 otherwise.

$\theta_2 NIIs, \theta_2 OBSs\ and \theta_2 LL\Pr$ are interaction variables in terms of non-interest income share, off-balance-sheet share and loan loss provision ratio, respectively. This is equal to the original value of variables for the period 2001-2006, and 0 otherwise.

$\theta_3 NIIs, \theta_3 OBSs\ and \theta_3 LL\Pr$ are interaction variables in terms of non-interest income share, off-balance-sheet share and loan loss provision ratio, respectively. This is equal to the original value of variables in 2007, and 0 otherwise.

i=1,…, 359 (individual bank).

j= 1,..., 7 (individual country).

t=1996,…, 2007 (year).

c is a constant.

[21] Interbank operation in the US is usually overnight; thus, we use federal funds rates as a replacement in this work. Data source: Datastream.

κ is a time fixed effect

λ is a bank fixed effect.

ε is an error term.

2.4.2 Extended Estimation

The extended estimation aims to identify the scenarios described in the framework as shown in Figures 2-4, 2-5 and 2-6 in the three sub-periods (1996-2000, 2001-2006 and 2007), considering the shift in both OBSs and loans' curves leading to different proportions of the composition of a bank portfolio. In this study, therefore, we examine the effect of both OBSs and loans on bank profitability in order to show an optimal bank portfolio in different sub-periods. The empirical model is therefore shown as below:

$$Y_{i,j,t} = c + \theta_1 OBSs_{i,j,t1} + \theta_2 OBSs_{i,j,t2} + \theta_3 OBSs_{i,j,t3} + \delta_1 LOAN_{i,j,t1} + \delta_2 LOAN_{i,j,t2} + \delta_3 LOAN_{i,j,t3} + a_2 NIIs_{i,j,t} + a_3 LLPr_{i,j,t} + b_1 GDP_{j,t} + b_2 Interb_{j,t} + k_t + \lambda_i + \varepsilon_{i,j,t} \quad (\text{Ⅳ})$$

where,

$LOANs = LOAN / TA$, a proxy of traditional activities is associated with less risk-taking compared with OBSs.

$\delta_1 LOAN_{i,j,t1}, \delta_2 LOAN_{i,j,t2} and \delta_3 LOAN_{i,j,t3}$ are interaction variables of the loan ratio for three sub-periods 1996-2000, 2001-2006 and 2007, respectively.

2.4.3 Empirical Model with Capital Requirement

This estimation is based on the theoretical work related to the effect of capital requirement on the selection of a bank portfolio. In this empirical model, following the basic and extended

empirical models, banks are assumed to be involved in traditional and non-traditional behaviour to make profits. Thus, we use OBSs as a measure of non-traditional bank activities and loans as a measure of traditional bank activities. Bank risk-taking and macro-shocks are included in this work. The year dummy variable is used to capture the time specific effect of changes in banking structure and financial systems. Since we show the effect of OBSs and loans on the Sharpe ratio (SR) in the theoretical work, risk-adjusted bank performance is used in the estimation. Without considering risk-based capital regulation, the empirical model is shown:

$$Y_{i,j,t} = c + a_1 NIIs_{i,j,t} + a_2 OBSs_{i,j,t} + a_3 LOANs_{i,j,t} + a_4 LLPr_{i,j,t} + b_1 GDP_{j,t} + b_2 Interb_{j,t} + D\_year + k_t + \lambda_i + \varepsilon_{i,j,t} \quad (2\text{-}13)$$

where,

Y includes two variables, one is return on asset as a measure of bank profitability following the basic model, the other is risk-adjusted performance as a measure of SR and it is defined as the return on asset to the standard deviation of return on asset (calculated over the sample period for a bank), following Stiroh and Rumble (2006).

D_year is year dummy variables to capture the time specific effect, taking 1996 as a base.

Basel Accord II proposed a risk-based capital regulation to require that banks hold sufficient capital accordingly to the risk weights of asset categories. When facing a heavy capital requirement, banks have to either increase capital holdings or reduce risky assets in order to meet the requirement. Francis and Osborne (2009) and Furfine (2001) suggest that the adjusted cost of raising capital is higher than other bank assets, so banks are inclined to change the composition of portfolios, and this highlights the substitute effect between

traditional activities and non-traditional activities. According to the Basel Agreements, a risk-based capital requirement sets a target ratio to risk weights at 8%, thus we attempt to investigate the effect of capital requirement on bank portfolio selection in two cases, one when the capital ratio is above 8% and the other when it is below 8%[22].

The theoretical model suggests that without considering risk-based capital regulation, banks prefer holding the same proportion of traditional bank behaviour and OBSs; while under a risk-based capital requirement, banks choose fewer OBSs than traditional bank activities against higher regulatory costs. This suggests that the capital regulation may have a negative effect on bank performance when choosing more OBSs. Therefore, recalling Eq. 2-13, an empirical model to check the impact of capital requirement on bank performance is indicated below:

$$Y_{i,j,t} = c + a_1 NIIs_{i,j,t} + a_2 OBSs_{i,j,t} + a_3 LOANs_{i,j,t} + a_4 LLPr_{i,j,t} + a_5 TA_{i,j,t} + \lambda_1 LOANs * d\_cap + \lambda_2 OBSs * d\_cap + b_1 GDP_{j,t} + b_2 Interb_{j,t} + D\_year + k_t + \lambda_i + \varepsilon_{i,j,t} \quad (2\text{-}14)$$

where,

d_cap is a dummy variable and is equal to 1 when capital ratio is more than 8%, 0 otherwise.

*LOANs*d_cap* is an interaction variable to identify the effect of capital regulation on traditional activities, i.e., loans. According to the implications of the theoretical model, we expect that regarding traditional activities, serious capital regulation may have less or little impact on bank performance given the lower risk-taking of traditional activities, so banks are willing to choose more traditional activities instead of OBSs.

[22] Based on the sample in this chapter, 138 of 359 banks held at least 8% capital from 1996 to 2007; this might be because Basel Accord II which requires no less than 8% capital holding was addressed in 2004.

*OBSs*d_cap* is an interaction variable to identify the effect of risk-based capital requirement on OBSs. Based on the conclusion of the model, we expect that an increase in OBSs leads to a decline in bank returns, as banks have to pay higher level regulatory costs when choosing more OBSs, which has a negative effect on bank performance. Therefore, in this context, banks prefer holding traditional activities. Table 2-4 shows a summary of the statistics and definitions of variables. Table 2-3 shows the matrices of correlation among bank-level variables.

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Table 2-3 The Matrices of Correlation among Bank-level Variables

	ROA	NNIs	OBSs	LOANs	LLPs
ROA	1.000				
NNIs	0.141	1.000			
OBSs	0.114	0.382	1.000		
LOANs	0.122	0.042	0.016	1.000	
LLPs	-0.032	0.278	-0.007	0.441	1.000

Note: ROA is the percentage of net income to total assets; NNIs is the percentage of net non-interest income to total operating income; OBSs is the percentage of off-balance-sheet items to total assets; LOANs is the percentage of loans to total assets; LLPs is the percentage of loan loss provisions to total assets.

Table 2-4 Summary Statistics and Definitions of Variables

Year	Income	NNIs	OBSs	LOANs	LLPr	GDP	Interbank
Definition	The percentage of net income to total assets	The percentage of net non-interest income to total operating income	The percentage of off-balance-sheet items to total assets	The percentage of loans to total assets	The percentage of loan loss provisions to total assets	GDP growth rate as the ratio of the difference between the current year and the last year to the value of last year	Interbank rates (3-month) for the European countries; Federal Funds rates (middle rate, overnight)
1996	0.663	1.414	9.956	73.492	0.321	3.831	4.286
1997	0.616	1.124	9.283	73.860	0.309	4.160	4.416
1998	0.633	1.667	9.339	73.418	0.340	4.312	4.381
1999	0.585	1.365	9.264	73.345	0.294	4.398	3.929
2000	0.670	1.515	10.582	72.253	0.336	5.347	5.248
2001	0.626	2.202	10.550	72.181	0.368	3.304	3.965
2002	0.638	1.667	11.683	73.639	0.362	3.228	2.880
2003	0.690	2.018	13.779	74.230	0.345	3.185	2.117
2004	0.688	1.885	15.335	72.397	0.269	4.585	2.216
2005	0.754	3.081	17.343	71.964	0.211	4.555	2.833
2006	0.788	2.188	17.764	71.320	0.212	5.281	3.952
2007	0.669	2.042	19.790	72.325	0.203	5.020	4.807
Mean	0.666	1.786	12.418	72.615	0.294	4.267	3.752
Std.	0.479	10.897	15.317	15.280	0.532	1.481	1.314
Max	0.840	79.150	49.659	99.800	3.602	6.633	7.35
Min	0.004	0.000	0.000	1.832	0.000	0.940	1.22

Note: Data of each year is mean values of various variables across banks; Data of Mean, Std., Max and min are presented across the entire period 1996-2007; GDP is an average of GDP growth rate across countries in each year. Sources: Authors' computation; Bankscope and Datastream.

2.5 Econometric Methodology with Panel Data

The two main methods to fit the regression with panel data are the fixed effect model and random effect model. According to Wooldridge (2006, pp485-493), given a panel data set, the estimated regression is shown as:

$$y_{i,t} = X_{i,t}\alpha + \gamma_i + \varepsilon_{i,t} \tag{2-15}$$

where,

y is a dependent variable.

X is a vector of independent variables.

α is a vector of coefficients of X.

γ is an unobserved individual-level effect.

ε is a disturbance term.

$i = 1,\ldots,n$ is the number of units and $t = 1,\ldots,T$ is the number of years.

Either the fixed effect model or the random effect model can be applied in Eq. 2-15, which depends on whether the unobserved effect γ and X are correlated. Thus, two approaches are respectively introduced as follows.

2.5.1 The Fixed Effect Model

Assume that an unobserved unit-level effect (the fixed effect) γ is correlated with explanatory variables, which leads to biased and inconsistent coefficients. Thus, one reasonable approach to eliminate the fixed effect is shown.

For unit *i*, the averages of variables in Eq. 2-15 over time are respectively generated and presented as follows.

$$\bar{y}_i = T^{-1}\sum_{t=1}^{T} y_{i,t} \quad , \quad \bar{X}_i = T^{-1}\sum_{t=1}^{T} X_{i,t} \text{ , and } \quad \bar{\varepsilon}_i = T^{-1}\sum_{t=1}^{T} \varepsilon_{i,t}$$

Since the unobserved unit-level effect is fixed, $\bar{\gamma}_i = \gamma_i$. Therefore, we subtract the averages from Eq.2-15,

$$y_{i,t} - \bar{y}_i = (X_{i,t} - \bar{X}_i)\alpha + (\gamma_i - \bar{\gamma}_i) + (\varepsilon_{i,t} - \bar{\varepsilon}_i) \tag{2-16}$$

Or

$$\ddot{y}_{i,t} = \ddot{X}_{i,t}\alpha + \ddot{\varepsilon}_{i,t} \tag{2-17}$$

According to Eq. 2-17, the fixed effect estimator $\hat{\alpha}_{FE}$ can be obtained using the OLS.

2.5.2 The Random Effect Model

The key difference between the fixed effects model and the random effects model is whether unobserved effect is correlated with independent variables. The random effects model assumes that there is zero correlation between the unobserved effect and explanatory variables, i.e., cov (γ , X)=0, so γ can be an additional random disturbance.

$$y_{i,t} = X_{i,t}\alpha_k + \eta_{i,t} \tag{2-18}$$

where,

$\eta_{i,t} = \gamma_i + \varepsilon_{i,t}$, and it is a composite error term.

As the fixed effect γ_i is in the composite error term over time, the serial correlation is indicated.

$$Corr(\eta_{i,t}, \eta_{i,l}) = \sigma_\gamma^2 \Big/ (\sigma_\gamma^2 + \sigma_\varepsilon^2), \quad (t \neq l) \tag{2-19}$$

where,

$Corr(\eta_{i,t}, \eta_{i,l})$ is the serial correlation in the error term.

$\sigma_\gamma^2 = Var(\gamma_i)$, and is the variance of the unobserved effect.

$\sigma_\varepsilon^2 = Var(\varepsilon_{i,t})$, and is the variance of the disturbance term.

As pooled OLS standard errors cannot eliminate the serial correlation, generalised least squares (GLS) should be employed to estimate models with serial correlation. Thus, the Eq. 2-18 is transformed and shown as follows:

$$y_{i,t} - \lambda\bar{y}_i = \alpha_k(X_{i,t} - \lambda\bar{X}_{i,t}) + (\eta_{i,t} - \lambda\bar{\eta}_i) \tag{2-20}$$

where,

$\lambda = 1 - [\sigma_\varepsilon^2 / (\sigma_\varepsilon^2 + T\sigma_\gamma^2)]^{0.5}$ and it can be estimated:

$\hat{\lambda} = 1 - \{1/[1 + T(\hat{\sigma}_\gamma^2 / \hat{\sigma}_\varepsilon^2)]\}^{0.5}$

where,

$\hat{\sigma}_\gamma^2 = [NT(T-1)/2 - (k+1)]^{-1} \sum_{i=1}^{n} \sum_{t=1}^{T-1} \sum_{l=t+1}^{T} \hat{\eta}_{i,t} \hat{\eta}_{i,l}$ is an estimator of σ_γ^2 with $\hat{\eta}_{i,t}$ and $\hat{\eta}_{i,l}$, which are residuals from estimating Eq. 2-18 by using pooled OLS.

$\hat{\sigma}_\varepsilon^2 = \hat{\sigma}_\eta^2 - \hat{\sigma}_\gamma^2$, and it is an estimator of σ_ε^2.

$\hat{\sigma}_\eta^2$ is the square of the standard error of Eq. 2-18 by using pooled OLS.

Using $\hat{\lambda}$ instead of λ in Eq.2-20 can obtain the random effects estimators, which are consistent and asymptotically normally distributed.

2.5.3 Hausman Test

This study aims to investigate the effect of OBSs on bank performance. The unobserved effects, including the bank's age, the experience of bank managers, the qualification of employees and the technological level, contribute to the development of OBSs and the efficiency of OBSs management, so they may have a significant correlation with explanatory variables, such as OBSs and non-interest income. Thus, the fixed effect model can be acceptable in this estimation. However, in order to identify whether the fixed effect model or random effect model is appropriate, a standard approach Hausman test (Wooldridge, 2002, p288) should be used, which is constructed to compare the estimators of the fixed effect model and random effect model. The original form of the Hausman statistic (HS) is shown as follows.

$$HS = (\hat{\alpha}_{FE} - \hat{\alpha}_{RE})'[\hat{Var}(\hat{\alpha}_{FE}) - \hat{Var}(\hat{\alpha}_{RE})]^{-1}(\hat{\alpha}_{FE} - \hat{\alpha}_{RE}) \quad (2\text{-}21)$$

where,

$\hat{\alpha}_{FE}$ represents the vector of coefficients in terms of the fixed effect estimation.

$\hat{\alpha}_{RE}$ represents the vector of coefficients in terms of the random effect estimation.

$\hat{Var}(\hat{\alpha}_{FE})$ represents the variance-covariance matrix of coefficients based on the fixed effect estimation.

$\hat{Var}(\hat{\alpha}_{RE})$ represents the variance-covariance matrix of coefficients based on the random effect estimation.

The Hausman statistic is distributed asymptotically as Chi-square with the degree of freedom equal to the number of explanatory variables. The null hypothesis is that the unobserved effect is uncorrelated with the explanatory variables, so that we can reject the fixed effect model, as it includes an unnecessary dummy variable set. The alternative hypothesis is that the unobserved effect is correlated with the explanatory variables, which generates biased and inconsistent estimators. Thus, we accept the fixed effect model, as it is systemically different from the random effect model. The results of the Hausman test are reported in Tables 2-4 and 2-5. In this study, the Chi-square values are more than the critical value, given that *P*-value is zero, so we can reject the null hypothesis and use the fixed effect model in the estimations.

2.6 Empirical Results and Analyses

2.6.1 Results of Empirical Models

Table 2-5 displays the results of four empirical estimations. Regression Ⅱ is used to identify the scenario described in the framework as shown in Figure 2-3. A negative and significant result of OBSs in the sub-period 2001-2006 indicates that an increase in OBSs leads to a lower level return, which is inconsistent with the implication of the framework; this result suggests that an optimal strategy for banks is to be involved in less OBSs post-2000 owing to a large proportion of OBSs being associated with higher risk-taking. However, it is consistent with the results of empirical work investigated by Stiroh (2002), Stiroh (2006) and Calmes and Theoret (2010), who imply that idiosyncratic risk is diversified due to the employment of product diversification, but the overall portfolio risk is higher and cannot be diversified; and higher leverage ratio also contributes to this negative effect of OBSs with complex characteristics. A negative and significant coefficient of OBSs on bank profitability in 2007 follows the scenario indicated in the framework (see Figure 2-3), suggesting that, because of abnormal higher risk-taking and leverage, an increase in OBSs leads to lower bank returns.

The second column of Table 2-5 displays the results of Regression Ⅰ, which investigates the effect of NIIs in three sub-periods. Basically, the signs of the results follow those of the OBSs in Regression Ⅱ. The negative coefficients of *NIIs* in sub-periods 2001-2006 and 2007 suggest that non-traditional activities associated with non-transparent and complex characteristics increase the volatilities of bank income. This is consistent with the conclusion of the standard portfolio theory, suggesting that a positive correlation between traditional activities and non-traditional activities restricts the diversified benefits. These results are also consistent with the implications of empirical estimations (Stiroh, 2004ab and Stiroh, 2006)

which argue that the cross-selling of banking products might create a positive correlation between traditional activities and non-traditional activities income, since a stable and long-run relationship with clients in terms of traditional activities can be used in financial operations with non-traditional activities. The European Commission (2006) also points out that customers' preferences rarely change over time, so banks usually provide a diversified financial product to the same clients. Therefore, the diversified gains are reduced.

The fourth column of Table 2-5 shows the results of Regression Ⅲ, which aims to examine the effect of LLPr on bank performance during three sub-periods. The negative and significant coefficients indicate that bank credit risk has an impact on bank returns in the three sub-periods. Generally, this result follows the conclusions of the empirical estimations of Demirgüç-Kunt and Huizinga (1998), Nys (2003), Fonseca and González (2007), Baele *et al*. (2007), Chen (2007), and Calmès and Théoret (2010). They argue that the default risk of traditional activities, i.e., loans, still has an impact on bank performance, even when there is a significant increase in OBSs in a bank portfolio. In addition, considering credit rationing, an increase in the supply of loans raises bank risk-taking beyond the threshold of interest rate, this requires banks to hold more LLP against the potential higher risk level. Thus, it has a negative impact on bank profitability.

The last column of Table 2-5 shows the results of regression Ⅳ, which aims to examine the effect of the composition of a bank portfolio on bank profitability due to the shift in the capacity of bank activities including both OBSs and loans in the three sub-periods. Taking the period pre-2000 as a basis, although an insignificant coefficient of OBSs is found in pre-2000, the magnitude of the negative effect of OBSs increased in 2001-2006 and 2007, and the

positive effect in terms of loans slightly reduced over time. The negative result of OBSs and positive result of loans on bank profitability in 2001-2006 support the scenario described in the third and fourth cases as shown in Figures 2-5 and 2-6[23] (see A' in equilibrium), suggesting that an increase in the proportion of OBSs and a reduction in the proportion of loans in the bank portfolio lead to a lower bank return than pre-2000 in equilibrium. This shows an overcapacity problem, especially with OBSs (Milne and Wood, 2003), since banks have an incentive to enlarge the capacity of bank activities in order to participate in a potential bail-out provided by the government under TBTF; however, risk management is not able to efficiently control for the risk-taking of a large proportion of OBSs with complex characteristics, so the overall portfolio risk is higher, which has a negative impact on bank profitability. The negative result of OBSs and positive result of loans in 2007 support the scenario described in the framework as shown by Figures 2-5 and Figure 2-6[24], suggesting regarding bank capacity, either an increase in loans or a reduction in loans, as long as an increasing shift of OBSs is more than that of loans, leading to a higher proportion of OBSs and lower proportion of loans in a portfolio in equilibrium where the bank expected return is reduced due to an abnormal higher risk and leverage resulting from inappropriate bank regulation. This negative effect is consistent with the situation of the financial markets in 2007. Based on these results, the conjecture is that the optimal bank portfolio selection is banks should go for more traditional activities than non-traditional activities.

[23] The negative result of OBSs and positive result of loans in post-2000 follow the scenario of the equilibrium described in the framework as shown in Figures 2-5 and 2-6; these figures indicate that, regarding bank capacity, the shift of OBSs is more than that of loans (though it cannot be tested through the empirical work, this is reasonable due to competition in traditional credit markets, regulation of traditional bank activities and higher profits of non-traditional activities mentioned by many previous papers), and this leads to a lower return with a higher proportion of OBSs and lower proportion of loans in equilibrium compared with pre-2000.

[24] Figure 2-5 shows that the shift of OBSs is more than that of loans regarding the bank capacity in 2007, leading to a lower bank return with a higher proportion of OBSs and lower proportion of loans. Although Figure 2-6 shows a different case, in that the shift of loans is down but the shift of OBSs is up in 2007, this leads to the same consequence: a lower return with a higher proportion of OBSs and lower proportion of loans in the bank portfolio.

Regarding the effect of macro-variables, we find a positive and significant effect of the macro-economy on bank performance in all estimations, which is consistent with numerous studies (see Bikker and Hu, 2002; Gerlach et al., 2004; Fonseca and González, 2007). They argue that the rapid economic development provides an opportunity for the banking sector to diversify the credit risk of bank activities, which has a positive impact on bank performance in a boom. However, as suggested by Kashyap *et al*. (2002), householders prefer deposit-taking in downturns, since deposit insurance is imposed as a protection against potential risk, which might reduce investment in non-traditional activities. This result supports a positive relationship between bank performance and economic growth.

Basically, the empirical results of Regression Ⅱ cannot support the scenario in the sub-period 2001-2006 described in the framework as shown in Figure 2-3. An increase in OBSs leads to a lower level of return, since banks are unable to manage the risk of OBSs (inefficient risk management) which causes the overall portfolio risk to be increased; and inappropriate regulation also contributes to this negative effect; the results of Regression Ⅰ are consistent with the argument that a positive correlation between traditional activities and non-traditional activities (cross selling) restricts diversified gains; the results of Regression Ⅲ suggest the negative effect of higher risk-taking of traditional activities on bank performance, considering credit rationing. According to the results of OBSs and loans of Regression Ⅳ in the three sub-periods, we argue that an increase in the capacity of bank activities, especially an increasing shift in OBSs, has a negative impact on bank profitability, which support the scenario described in the frameworks as shown in Figures 2-5 and 2-6. A large proportion of OBSs associated with an abnormal higher risk and leverage has a negative impact on bank performance; therefore, an overcapacity problem is generated so that the introduction of

risk-based capital regulation might be used to control for the composition of bank portfolios.

Table 2-5 Results of Estimations

Independent variables	Regression (Ⅰ)	Regression (Ⅱ)	Regression (Ⅲ)	Regression (Ⅳ)
NIIs	----	-0.01 [-1.48]	-0.03*** [-3.00]	-0.04* [-1.74]
OBSs	-0.07*** [-5.384]	----	-0.005* [-1.666]	----
LLPr	-0.04*** [-4.00]	-0.08*** [-5.94]	----	-0.08*** [-5.70]
GDP	0.035** [2.916]	0.048*** [5.10]	0.029** [2.416]	0.06*** [6.23]
Interb	-0.002 [-0.133]	-0.012 [-0.80]	-0.007 [-0.50]	-0.01 [-0.91]
NII1	0.001 [0.03]	----	----	----
NII2	-0.015** [-2.143]	----	----	----
NII3	-0.04** [-2.353]	----	----	----
OBS1	----	-0.011 [-0.73]	----	-0.007 [-0.45]
OBS2	----	-0.024** [-2.47]	----	-0.024** [-2.28]
OBS3	----	-0.034*** [-3.28]	----	-0.033** [-2.98]
LOAN1	----	----	----	0.432*** [5.42]
LOAN2	----	----	----	0.365*** [5.11]
LOAN3	----	----	----	0.359*** [4.79]
LLP1	----	----	-0.11*** [-7.333]	----
LLP2	----	----	-0.08*** [-5.714]	----
LLP3	----	----	-0.07*** [-3.333]	----
Constant	-5.66*** [-53.904]	-5.281*** [-42.934]	-5.166*** [-74.74]	-4.67*** [-19.94]
No.of Obs.	3444	3391	3458	3459
Adjusted R-square	0.697	0.70	0.69	0.69
Hausman test Chi2	184.98***	195.48***	193.50***	275***

Notes: NII1, OBS1, LOAN1 and LLP1 are interaction variables of non-interest income share, off-balance-sheet, loan ratio and loan loss provision ratio for the sub-period 1996-2000; NII2, OBS2, LOAN2 and LLP2 are interaction variables of non-interest income share, off-balance-sheet, loan ratio and loan loss

provision ratio for the sub-period 2001-2006; NII3, OBS3, LOAN3 and LLP3 are interaction variables of non-interest income share, off-balance-sheet, loan ratio and loan loss provision ratio for the sub-period 2007; ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively. t-statistics are in[].

2.6.2 Results of Estimation with Capital Regulation

As we identified an overcapacity problem in the bank portfolio, we have to estimate whether efficient capital regulation can control for this and lead to better bank performance. The second and third columns of Table 2-6 present the results of the regression (Eq. 2-13) using two different proxies of bank performance (ROA and Risk-adjusted performance[25]), which aim to identify an optimal bank portfolio without considering risk-based capital regulation. An increase in OBSs and a reduction in loans have a negative impact on bank profitability considering ROA as a dependent variable. In essence, this result is consistent with previous estimations. In addition, considering risk-adjusted performance as a dependent variable, we find a negative and significant coefficient of the interbank rate, suggesting that an increase in interbank rate reduces risk-adjusted bank return. Taking the interbank rate as a risk-free rate, if it is going up, the SR is going down based on the portfolio theory.

The fourth and fifth columns of Table 2-6 report the results of the estimations including two interaction variables (recalling Eq. 2-14), in order to identify the effect of capital requirement on bank performance. The significant and negative coefficients of the interaction variable between OBSs and the capital requirement dummy are found in two estimations (ROA and risk-adjusted performance), which suggest that under a risk-based capital requirement, an increase in OBSs leads to a lower level of bank returns. However, insignificant coefficients of the interaction term between loans and the capital requirement dummy variables suggest that a

[25] Risk-adjusted performance as a measure of SR is defined as the return on asset to the standard deviation of return on asset (calculated over the sample period for a bank), following Stiroh and Rumble (2006).

risk-based capital requirement has little impact on loans associated with lower risk-taking, compared with OBSs. These results follow the implications of the theoretical model, as shown in Figure 2-8, which highlights a substitute effect and suggests that banks should choose more traditional activities than OBSs as an optimal investment strategy, owing to heavy regulatory costs imposed on OBSs.

Regarding year dummy variables in terms of ROA estimations, we can identify a significant time specific effect since 2002. An increase in bank profits over time may result from the fast development of financial markets, i.e., new financial products, in the developed countries, while it reduced in 2007 due to the consequence of the recent financial crisis. Based on risk-adjusted performance estimations, most of the year dummies are insignificant.

Basically, the empirical results from these estimations follow the conclusions of the theoretical work as shown in Figure 2-8. Given a risk-based capital requirement, banks should hold traditional activities more than OBSs in equilibrium, since a considerable regulatory cost is granted to OBSs associated with higher risk-taking. This result highlights the substitute effect between OBSs and loans in the bank portfolio, given a risk-based capital requirement, and provides a solution for the overcapacity problem, especially regarding OBSs.

Table 2-6 Results of Robust Estimations

Independent variables	Estimation (1)		Estimation (2)	
	ROA	ROA/SDROA	ROA	ROA/SDROA
OBSs	-0.030***	-0.100***	-0.023**	-0.09***
	[-2.89]	[-5.37]	[2.16]	[-4.84]
LOANs	0.625***	0.061	0.58***	0.129
	[7.15]	[0.91]	[7.22]	[1.14]
NIIs	-0.008*	0.007	-0.01*	0.007
	[-1.76]	[1.48]	[-1.75]	[1.50]
LLPr	-0.072***	-1.106***	-0.073***	-0.106***
	[-5.16]	[-4.45]	[-5.19]	[-4.46]
GDP	0.024*	0.115***	0.023*	0.116***
	[1.94]	[5.17]	[1.90]	[5.19]
Interb	-0.012	-0.057**	-0.014	-0.059**
	[-0.81]	[-2.07]	[-0.94]	[-2.14]
OBS*d_cap	----	----	-0.025**	-0.032*
			[-2.26]	[-1.90]
LOAN*d_cap	----	----	-0.021	0.147
			[-1.58]	[0.75]
D_1997	-0.015	-0.057	-0.014	-0.058
	[-0.34]	[-0.74]	[-0.33]	[-0.73]
D_1998	0.016	-0.166**	0.016	-0.17**
	[0.34]	[-2.03]	[0.35]	[-2.07]
D_1999	-0.064	-0.304***	-0.063	-0.307***
	[1.38]	[-3.66]	[-1.35]	[-3.70]
D_2000	0.057	-0.127	0.061	-0.126
	[1.11]	[-1.42]	[1.21]	[-1.41]
D_2001	0.064	0.029	0.065	0.027
	[1.38]	[0.36]	[1.41]	[0.34]
D_2002	0.117**	0.065	0.117**	0.06
	[2.23]	[0.74]	[2.23]	[0.68]
D_2003	0.251***	0.069	0.251***	0.065
	[4.17]	[0.70]	[4.17]	[0.66]
D_2004	0.242***	-0.175*	0.244***	-0.18*
	[3.72]	[-1.67]	[3.73]	[-1.72]
D_2005	0.331***	-0.02	0.336***	-0.022
	[5.39]	[-0.22]	[5.47]	[-0.23]
D_2006	0.416***	0.038	0.423***	0.035
	[6.47]	[0.41]	[6.56]	[0.38]
D_2007	0.286***	-0.368***	0.294***	-0.369***
	[4.29]	[-4.03]	[4.41]	[-4.03]
constant	-3.85***	2.66***	-3.81***	2.56***
	[13.74]	[14.07]	[-13.57]	[10.79]
No. of groups	358	358	358	358
No. of Obs.	3396	3356	3396	3566
WithinR-square	0.04	0.05	0.04	0.05
HausmanChi 2	341.95***	151.27***	369***	100***

***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively.

2.7 Conclusions

Most of the empirical evidence on the effect of non-traditional activities on bank performance is limited to studies based on US banks, and does not present an optimal bank portfolio selection including traditional and non-traditional activities. This chapter attempts to empirically estimate both the US and the European banks, and further presents an optimal bank portfolio considering OBSs and loans as a whole both in the run-up to the financial crisis and during the crisis period.

We present two frameworks considering credit rationing: one is that, given a fixed capacity of bank activities, a shift of OBSs leads to an increasing proportion of OBSs in the bank portfolio with different expected returns in equilibrium in three sub-periods (1996-2000; 2001-2006 and 2007); the other is that, considering a change in the capacity of bank activities, the shift of OBSs and loans curves leads to different proportions of OBSs and loans in the bank portfolio with different expected returns in equilibrium in the three sub-periods. In addition, we present a theoretical model to show an optimal bank strategy in two cases, one considering risk-based capital regulation, and the other not doing so.

Based on the results of the empirical models for the three sub-periods, we conclude that the relationship between bank return and OBSs is negative, while there is a positive link between bank returns and loans, supporting the scenario described in the framework as shown in Figures 2-5 and 2-6. Since in some circumstances, banks are unable to diversify overall portfolio risk and effectively manage the risk of non-traditional activities, leading to higher risk-taking; and higher leverage resulting from inappropriate bank regulation also contributes to the negative effect of OBSs on bank performance. In addition, based on standard portfolio

theory, a positive correlation between interest income and non-interest income, owing to the cross-selling of financial products, decreases the benefits of bank diversification (Stiroh, 2004a, 2004b and Stiroh, 2006). Although the economies of scale enable the long-run average costs of bank operations to be reduced, overcapacity regarding OBSs, should be considered, which may lead to a higher risk level of bank portfolios. In addition, the negative effect of credit risk measured by loan loss provisions on bank performance is found in the three sub-periods and a significant positive relationship between bank performance and the macro-economy is also identified in this study.

The results of the empirical models considering risk-based capital regulation can support the implications of the theoretical model, suggesting that banks should choose more traditional activities as an optimal bank strategy when facing heavy regulatory costs. Risk-based capital regulation forces banks to shift away from risky assets to those with lower risk-taking, which highlights the substitute effect between these two activities and might solve the overcapacity problem, especially regarding OBSs. Therefore, banks, prior to improving the capacity, should consider the risk-taking of both traditional activities and non-traditional activities; on the other hand, policy-makers should propose the cooperation of bank regulation from government, shareholders and depositors, on non-traditional bank behaviour to control for its higher risk-taking, which forces banks to consider the regulatory costs of risky assets and choose an optimal bank portfolio in order to maintain a stable financial system.

CHAPTER 3

THE BANK SIZE IN DETERMINING THE RISK LEVEL OF INTERBANK LENDING

3.1 Introduction

The interbank market is an important market for allocating liquidity between banks. On the one hand, a bank with a liquidity problem can borrow through the interbank market; on the other hand, a bank with excessive liquidity can lend credit to others. Thus, the interbank market eases the liquidity problem, and at the same time reduces the costs of holding liquidity, which increases the efficiency and stability of the financial markets.

The interbank market plays a role in risk-sharing between banks with credit linkage; however, it is also a source of contagion risk. On the one hand, contagion risk occurs in the event of a shortage of aggregate liquidity assets. In the context of the interbank market, an initial failure of a borrowing bank may spread to lending banks, especially those with fewer liquidity assets. Thus, the value of lending bank assets is reduced and not sufficient to satisfy the liquidity requirement; finally, the lending bank has to liquidate its long-run assets and this forces the

bank into bankruptcy. This is the contagion effect discussed by Freixas and Rochet (2008, p240). Figure 3-1 presents a simple framework of interbank markets with relation to contagion risk. Through the trading of the interbank market, an initial borrowing bank default will probably generate a contagion effect on a lending bank with less liquidity, which increases the risk level of the lending bank. On the other hand, since lending banks cannot judge whether borrowers have good or bad credit, particularly in financial markets associated with higher volatilities, banks are reluctant to lend for fear that others will be unable to honour their obligations, which triggers a drying up of liquidity in the interbank market (Goldsmith-Pinkham and Yorulmazer, 2010).

The contagion effect is more significant in a downturn, when lending banks prefer to charge higher interest rates in the interbank markets. For example, the average of 3-month interbank rates in the European financial markets increased from 3.952 in 2006 to 4.807 in 2007[26], as involvement in the interbank market may trigger a higher level of risk-taking for lending banks. The recent financial crisis of 2007-08 also leads us to question the advantage of relying on interbank markets to provide liquidity, considering the contagion risk.

The policy of "too big to fail" (TBTF) is considered in the context of interbank lending. According to the argument on the structure of interbank markets suggested by Freixas *et al*. (2000), lending banks are money centre banks (usually big banks)[27], which are connected with other banks, large non-financial firms and even governments, such that their failures have a negative impact on the whole economy. Thus, the central bank is willing to provide potential protection for big banks, which might enable them to become involved in risky activities

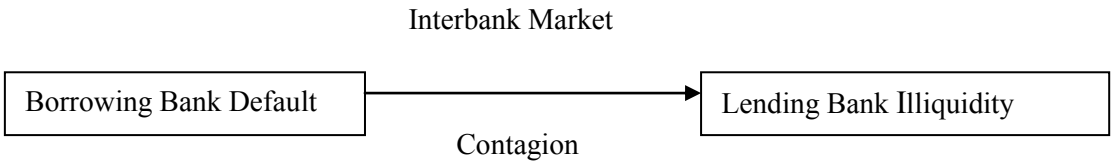
[26] Data source: Datastream.
[27] Because of advanced technology and information disclosure, management experience and stable relationships with customers in large banks, e.g. the Big Four in the UK, they occupy key positions, connected with the rest of the economy.

(moral hazard). The size effect, therefore, is significant in determining bank risk level.

In this study, we concentrate on the issue around whether involvement in interbank lending increases the risk level of banks: in this, the size effect should particularly be considered. We also detect differences in bank activities and risk-taking in the run-up to the recent crisis and during the crisis period through empirical analyses using data on banks from European countries and the US.

The rest of this chapter is organised as follows: a literature review on the interbank market is introduced in Section 2; econometric methodologies are discussed in Section 3; the model specification and data analyses are presented in Section 4; Section 5 presents the results and the analyses of the empirical estimations, and the last section concludes.

Figure 3-1 The Framework of Interbank Market



3.2 Literature Review

3.2.1 Market Structure and TBTF

Allen and Gale (2000), extended the original model of Bhattacharya and Gale (1987), to show two different structures of interbank markets: one is the interbank market with credit chains (incomplete market), where a bank has a connection only with its neighbour; and the other is the interbank market with diversified lending (complete market), where a bank has symmetric links with all others. Lower risk-taking is indicated in the complete market, where the risk of interbank lending can be shared by more than one lending bank. Considering the role of the central bank in the context of the interbank market, Freixas et al. (2000), based on the original model of Freixas et al. (1998), present a disconnected multiple money centres market structure (Figure 3-2), where borrowing banks have a connection with the money centre banks (A and E). The risk level of interbank trading depends on the position of the failed bank. The bankruptcy of the money centre bank leads to serious consequences for the financial system, since it is connected with other banks, large non-financial firms and even the government. This theoretical model highlights the role of the Central Bank (CB) and indicates that the optimal strategy of the CB is to provide additional protection for money centre banks in order to minimise the costs of intervention under TBTF. As shown in Figure 3-2, the CB, as the lender of last resort (LLR), would lend to a money centre bank having an illiquidity problem. In addition, the structure of the interbank market in many countries, such as Germany, Belgium and Austria, is characterised as a multiple money centre banks market (Figure 3-3), where the money centre banks have a connection between each other. Compared with the structure shown in Figure 3-2, the risk level is higher in the structure shown in Figure 3-3, where money centre banks are connected and the contagion effect in turn can be spread to other money centre banks that are linked together. To some extent, the implication of the

multiple money centre bank market structure is consistent with the policy of TBTF, that they are protected by CB and hence might be associated with a higher level of risk-taking owing to moral hazard.

Figure 3-2 Disconnected Multiple Money Centre Bank Market Structure (Freixas, Parigi and Rochet, 2000)

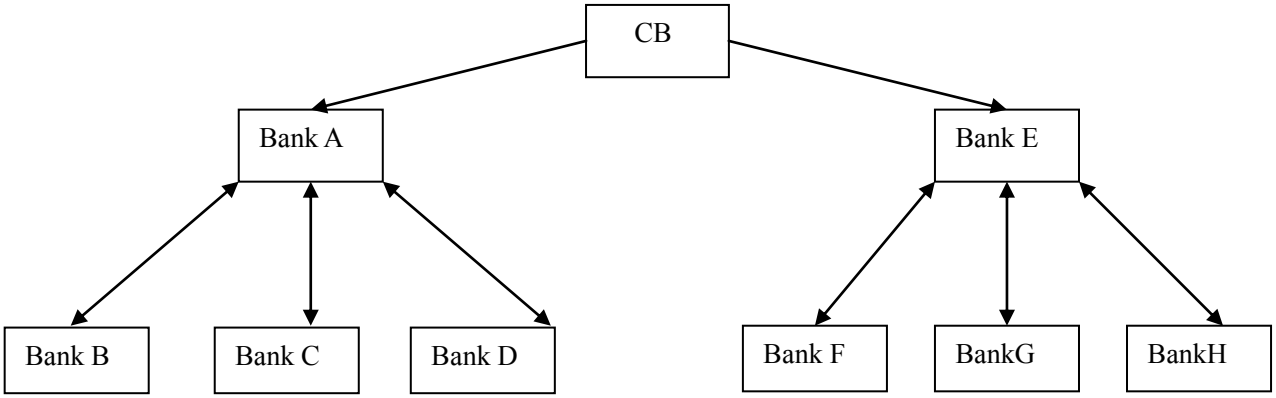
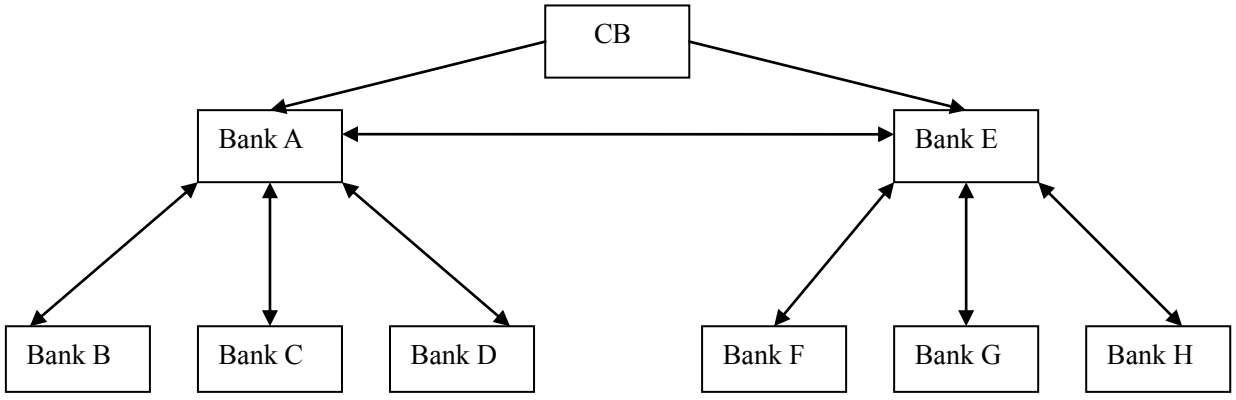


Figure 3-3 Interconnected Multiple Money Centre Bank Market Structure (Freixas, Parigi and Rochet, 2000)



According to the introduction to market structure and TBTF above, we may argue that under the development of interbank market structure, the money centre bank market structure highlights the important role of CB in maintaining a stable financial system. Given a multiple money centre bank market structure, CB is willing to rescue big banks that are in key positions of the economy considering TBTF, which may increase the incentives of big banks to be involved in risky activities, suggesting different risk levels in terms of large and small banks.

The existing empirical modelling has concentrated on the effect of the interbank market structure on risk-taking using matrix analyses[28]. In these studies, balance sheet data or large interbank exposures data are used as a proxy to determine the structure of interbank markets. Upper and Worms (2002) estimated the Germany interbank market by applying 25 matrices of bilateral exposures in terms of maturity and bank categories (saving banks, cooperative banks, commercial banks, Landesbanken and the cooperative central bank). They find that the German interbank market is two-tier: in the upper tier, the structure of interbank exposures is close to a complete interbank market structure (for savings banks and cooperative banks), while in the lower tier, the interbank market is associated with an incomplete structure (for commercial banks, Landesbanken and the cooperative central bank) and suggest that the contagion risk is lower in a complete market structure than in an incomplete market structure. Wells (2004) suggests that in the UK, large banks engage in operations between each other and the small banks borrow credits from large banks, which is consistent with the implications of the multiple money centre bank structure as suggested by Freixas *et al.* (2000). However,

[28] Basically, the idea of matrix analyses is that $x_{i,j}$ is credit exposure of bank j VS bank i (bilateral exposures), if the product of $x_{i,j}$ and the loss rate is bigger than the book value of bank i, suggesting that bank j trigger the failure of bank i.

Cocco *et al*. (2009) suggest that a different structure exists in the Portuguese interbank market, where large banks tend to be net borrowers as they have more opportunities to invest; while small banks specialise in deposit-taking but have few investments, so they having sufficient liquidity can lend to large banks. Degryse and Nguyen (2004) analyse the contagion effect using Belgian banks from 1993 to 2002. They stress the importance of interbank market structure in determining contagion risk. A change in market structure from a complete market to a multiple money centres market allows contagion risk to be reduced, since in some cases, the failure of borrowing banks (small banks) linked to a money centre bank cannot lead to the failure of the money centre bank protected by CB, which is consistent with the implications of the framework suggested by Freixas *et al.* (2000).

3.2.2 Bank Size and Monitoring

In the context of a money centre bank market structure, although large banks are often engaged in interbank operations as lenders, an increase in interbank assets might not lead to higher risk-taking. Rochet and Tirole (1996), using a theoretical model, highlight the importance of effective monitoring of the interbank assets of lending banks, which can reduce the risk of interbank lending and maintain a stable financial system. Dinger and Hagen (2005), comparing large and small banks, introduce a theoretical model to imply that large banks have more advantages, such as efficient management and economies of scale, in monitoring borrowing banks, and hence can reduce the risk level of interbank lending. In this model, there are assumed to be two firms: one with good projects and the other with bad projects. The rate of return of a good project is R_g with a probability of π_g, 0 otherwise; the rate of return of a bad project is R_b with a probability of π_b, 0 otherwise.

$R_g\ \pi_g$ -1>0> $R_b\ \pi_b$ -1, $R_g < R_b$ and $\pi_g > \pi_b$

For the banking sector, there is one large bank as a lending bank and *n* small banks as borrowing banks following the money centre bank market structure. The interest rate of deposit (i_{lb}) for the large bank is lower than that of the small banks (i_{sb}), since large banks receive government protection on deposits. The payment for depositors in the large bank is D_{lb}=1 due to its risklessness and for small banks, the nominal repayment is D=1+i_{sb}. Moreover, the large bank also provides interbank assets at the interbank rate i_{ib} according to the risk level of borrowing banks: if a borrowing bank usually finances bad projects, it would be required to pay a higher rate. The repayment for one unit of interbank asset is d=1+i_{ib}. Small banks can refinance through either deposit-taking or the interbank market. Thus, the deposit for small banks is *p* and the marginal cost of gathering deposits is c(p); alternatively, the amount of credits from the interbank market for small banks is *1-p-E*; *E* is the equity, and a higher level of equity reduces the amount of credit financed by either deposit-taking or the interbank market, and provides additional protection for banks.

Considering the moral hazard problem, small banks are willing to finance the bad project due to its higher return rate, even though they can assess the quality of this project. The small banks prefer to finance a good project if, and only if, the net return of the good project is not lower than that of the bad project:

$$\pi_g(R_g - R_i) - (1-\pi_g)(1-E) \geq \pi_b(R_b - R_i) - (1-\pi_b)(1-E)$$

where,

R_i is the repayment to creditors of small banks.

The repayment of interbank assets for the large bank is d_g when small banks finance a good project, and d_b when financing a bad project: $d_g < d_b$ and $d_g \pi_g > d_b \pi_b$.

This model discusses the net expected return (NER) of the large bank in four cases: both good and bad project success; bad project failure and good project success; good project failure and bad project success and both failing. By comparing NERs in these cases, this model finds that the large bank prefers to monitor borrowing banks and assure them to finance good projects in order to maximise NER, which reduces the default risk level of interbank lending. However, the monitoring only occurs if the benefit of screening is not lower than the fixed costs C, thus,

$$(1-E-p)d(\pi_g - \pi_b) \geq C \qquad (3\text{-}1)$$

The left-hand side of Eq.3-1 is the benefits measured by the difference in the expected return between two projects. Finally, the large bank is willing to monitor the borrowing banks if the amount of interbank lending exceeds the critical value $1-E-p \geq C \big/ d(\pi_g - \pi_b)$, otherwise, the large bank is not willing to monitor or is even reluctant to supply interbank loans.

According to the implications of this theoretical model, Dinger and Hagen (2009) empirically estimate the effect of interbank borrowing on bank risk using data on Central and Eastern European banks from 1995 to 2004. The reduced-form empirical model is shown as:

$$RISK = (INB, SIZE, SIZE^2, EQU, MV) \quad (3\text{-}2)$$

where,

RISK is risk-taking measured by loan loss provision, loan loss reverse and net charge-off to equity, respectively.

INB is measured by interbank borrowing to total assets.

SIZE is log bank assets.

$SIZE^2$ is size squared.

EQU is the equity ratio used to measure capitalisation.

MV is macro-variables, including GDP and inflation.

They suggest that the borrowing banks are associated with lower risk-taking, as the lending bank is willing to monitor the borrowing banks' activities to maximise its expected return. Banks with good capitalisation are indicative of lower risk-taking. Large banks are associated with a higher level of risk-taking, and a nonlinear (U-shaped) relationship between bank size and risk-taking is found. The U-shaped link implies that when the bank size goes beyond a certain level, the risk level is increased. Thus, the effect of bank size on risk-taking is nonlinear. The level of risk varies accordingly to whether the bank size is under or above this critical value. Finally, the authors find a close link between macro-economic growth and bank risk-taking: banks are found to have lower risk in upturns. It is worth noting that Dinger and Hagen's (2005) theoretical model does not take TBTF into account in investigating bank behaviour; therefore, in this chapter, we would like to modify this model by considering the difference between large and small banks (size effect), following the argument of Freixas *et al*. (2000), to investigate the risk-taking of interbank assets.

3.2.3 Macroeconomic Shocks

In addition to the explicit credit linkage, macroeconomic shocks also drive contagion risk. The theoretical model suggested by Elsinger et al. (2002), combining a network model of interbank exposures, estimates the level of credit risk in response to macroeconomic shocks, such as interest rate risk and exchange rate volatilities. Given the interbank market structure, the model suggests that default risk of the interbank market mainly results from macroeconomic shocks. Elsinger et al. (2006b) investigated two types of the reason of bank failure: one is fundamental risk-taking, e.g. the exposure to market, and the other is contagion risk resulting from other bank failures, using data on Austrian banks. The result shows that the majority of bank defaults (97%) are driven by fundamental shocks of banking system, while only 2.7% of bank defaults result from a chain reaction of other bank failures in the financial system, suggesting that fundamental risk factors are the source of bank default, systemic crises and financial instability. Moreover, the probability of bank failure is higher for small banks than large banks, which is consistent with the findings of Allen and Gale (2000) and Freixas et al. (2000) in the context of interbank markets, implying that large banks participate in a potential bail-out provided by CB.

From the literature review, we focus on the implications of the theoretical work (Dinger and Hagen, 2005) considering the effect of TBTF (Freixas et al., 2000). Freixas et al. (2000) suggest that given a multiple money centre bank market structure, CB as LLR is willing to protect large lending banks, in order to maintain a stable financial system. However, this may generate a higher level of risk-taking in large banks because of a moral hazard problem. Thus, the first assumption we attempt to examine is that large banks are associated with higher risk-taking under TBTF in this framework. According to Dinger and Hagen (2005)'s

theoretical model, as large banks have advantages in screening, in order to maximise the expected return, they prefer to monitor borrowing banks, which reduces the default risk level of interbank assets. However, considering the implication of Freixas et al. (2000), we may question this conclusion[29]. Given TBTF, large banks may have less incentive to monitor borrowers, which may increase the risk level of interbank assets. Thus, the second assumption is that an increase in interbank lending is associated with higher risk-taking for large banks. Based on Dinger and Hagen (2005), the third assumption is that higher equities or deposits can protect banks against the liquidity problem, particularly for small banks which lack protection from CB; and banks with good capitalisation are likely to engage in less risky operations[30]. Both of these models (Dinger and Hagen, 2005 and Freixas et al., 2000) highlight the importance of bank size[31] in determining bank risk level, indicating the difference between large and small banks.

3.3 Introduction of Methodology

3.3.1 Threshold model

This empirical work is based on the theoretical work of Dinger and Hagen (2005) considering the effect of TBTF suggested by Freixas et al. (2000) in the context of interbank markets. Regarding the first and second assumptions, bank size and interbank assets are our main concerns in the estimation; based on the third assumption, higher equities and deposits[32] would provide additional protections for banks, so they are also considered. In addition, Elsinger et al. (2002, 2006a,b) theoretically and empirically show the effect of fundamental

[29] Dinger and Hagen (2009) point out that large banks in developed countries, e.g. the US, have less incentive to monitor interbank lending considering TBTF, although they do not present an investigation into this issue.
[30] However, Calem and Rob (1999) suggest that banks with higher capital holding, especially above the minimum capital requirement are involved in more risky activities.
[31] Regarding the theoretical work of Dinger and Hagen (2005), bank size is related to the economies of scale, which reduce long-run average costs of bank activities, e.g. monitoring borrowers.
[32] We use a loan deposit ratio in this estimation, as this can reflect liquidity risk. An increase in the loan-deposit ratio suggests a higher liquidity risk level (Lepetit et al., 2008b).

systemic risk on bank performance, so the macro-variables should be used. Therefore, the explanatory variables in this work consist of interbank assets (INA), size effect (SIZE), deposits (LDR), equity (EQU) and macro-variables (MV) including GDP growth rate and interbank rate as a measure of the risk level of interbank markets. Firstly, following Dinger and Hagen (2009), we estimate a non-linear regression to identify the significant difference in risk-taking between large and small banks, further suggesting whether we can split the whole sample in terms of bank size. If we find significant results with different signs of bank size and bank size squared, then we can estimate based on the large and small bank sub-samples, respectively. Thus, the non-linear empirical model including INA, SIZE, LDR, EQU and MV is shown below:

$$Risk_{ijt} = Lasset_{ijt} + Lasset^{2}{}_{ijt} + interbankassetratio_{ijt} + loandeporatio_{ijt} + equityratio_{ijt} + GDP_{jt} + Interbankrate_{jt} + c + \varepsilon \quad (3\text{-}3)$$

The definitions of variables and the preliminary results in terms of this estimation are shown in Appendix 4. We are interested in the results of bank size and bank size squared. A negative and significant coefficient of bank size and a positive and significant coefficient of bank size squared indicate that there is a U-shaped relationship between risk-taking and bank size: this follows the result of Dinger and Hagen (2009), suggesting that there might be differences in the risk level of bank activities between large and small banks. Thus, we could endogenously find this critical value of bank size to divide the whole sample by using a threshold model. Hansen (1996) provides an econometric method to estimate the threshold model. The applications of a threshold model include sample splitting and separating, and multiple equilibriums. Hansen (1999) develops the threshold model with the fixed effect for panel data.

The basic estimated threshold model is shown as:

$$y_{it} = \alpha_i + \theta_1' x_{it} I(k_{it} \le \tau) + \theta_2' x_{it} I(k_{it} > \tau) + \varepsilon_{it} \quad (3\text{-}4)$$

where,

i is the number of individual sections, and *i*=1, 2 ….*N*.

t is time period, *t*=1, 2 ….*T*.

y_{it} is a dependent variable.

α_i is an individual effect.

x_{it} is a m-vector of independent variables.

θ_1 and θ_2 are the coefficients for different regimes divided by the threshold parameter τ .

k_{it} is a threshold variable.

τ is the threshold value.

I is an indicator function.

ε_{it} is an error term and follows a zero-mean process, $\varepsilon_{it} \sim (0, \sigma^2)$.

Two categories are classified by the threshold value τ , and using the ordinary least squares method, the slope coefficients θ can be estimated.

Khan and Senhadji (2001) develop the threshold model and apply it to an unbalanced panel. By using conditional least squares, the threshold value is determined by minimising the sum of square residuals. In our study, with an unbalanced data set, loan-deposit ratio and equity ratio are identified as two endogenous variables, because in some circumstances banks having a higher risk level are concerned about risky assets, so they tend to change their portfolios by

reducing the amount of loans or increasing equities; the relevant test of the endogeneity of these two variables will be shown in the next section. This allows us to use the method developed by Hansen (2000) and Caner and Hansen (2004), who show a threshold model considering instrumental variables. Based on their view, the estimated model is given as:

$$y_{it} = \theta_1^{'} z_{it} I(k_{it} \le \tau) + \theta_2^{'} z_{it} I(k_{it} > \tau) + \varepsilon_{it} \quad (3\text{-}5)$$

where,

z_i is a m-vector and is correlated with the error term ε_{it}, thus, it is endogenous. x_i is a k-vector (k≥m) and can be instrumental variables for z_{it}. The reduced-form model on the conditional expectation of z_{it} is shown:

$$z_{it} = \psi(x_{it,} \beta) + u_{it} \quad (3\text{-}6)$$

Where,

z_{it} is endogenous variables.

x_{it} is a k-vector of exogenous variables. If x_i is correlated with the endogenous variables but is uncorrelated with the error term, it can be the instrumental variable for z_i.

β is the coefficient vector.

u_{it} is a m*1 vector of the error term, assume that $E(u_{it} \mid x_{it}) = 0$.

Substituting Eq. 3-6 into Eq. 3-5, the transformation is shown:

$$y_{it} = \theta_1^{'} \psi_{it} I(k_{it} \le \tau) + \theta_2^{'} \psi_{it} I(k_{it} > \tau) + \omega_{it} \quad (3\text{-}7)$$

where,

$$\omega_{it} = \theta_1' u_{it} I(k_{it} \le \tau) + \theta_2' u_{it} I(k_{it} > \tau) + \varepsilon_{it}$$

Following the three-step method suggested by Caner and Hansen (2004), the first step is to estimate the coefficient β of the reduced-form function by using the least squares method. The second step is to identify the threshold parameter (τ) by using the predicted values of endogenous variables in the first step. The third step is to estimate the coefficients θ_1 and θ_2 by using the 2SLS method, given the threshold value. It is worth noting that the threshold variable is exogenous, which can guarantee the consistent estimators.

In this study, the bank size is the threshold variable as we attempt to estimate the difference in risk-taking between large and small banks, and loan-deposit ratio and equity ratio are identified as endogenous variables. According to this three-step method suggested by Caner and Hansen (2004), in the first step, we predict the endogenous variables (loan-deposit ratio and equity ratio) by using the one-year lagged variables of loan-deposit ratio and equity ratio as instruments; the relevant test of the validity of the instruments is given in the next section. The second step is to estimate the threshold variable (bank size) by using the predicted values of the endogenous variables. The third step is to estimate the slope coefficients by using 2SLS on two regimes identified by an estimated threshold parameter. Therefore, the basic nonlinear model Eq.3-3 can be changed in terms of the threshold model, which aims to estimate the differences in the bank risk level and bank activities between large and small bank groups. This is shown below:

$$LLP_{i,t,j} = \begin{cases} c + \alpha_1 TA_{i,t,j} + \alpha_2 Equity_{i,t,j} + \alpha_3 Loandep_{i,t,j} + \alpha_4 InterL_{i,t,j} + \alpha_5 GDP_{j,t} \\ +\alpha_6 InterR_{j,t} \quad (TA \geq \tau) \\ c + \lambda_1 TA_{i,t,j} + \lambda_2 Equity_{i,t,j} + \lambda_3 Loandep_{i,t,j} + \lambda_4 InterL_{i,t,j} + \lambda_5 GDP_{j,t} \\ +\lambda_6 InterR_{j,t} \quad (TA < \tau) \end{cases} \tag{3-8}$$

The key issue of the threshold model is to determine the threshold value (τ). Recalling the reduced form Eq.3-6, $z_{it} = \psi(x_{it,}\, \beta) + u_{it}$, the predicted values of z_i are shown as below:

$$\hat{z}_{it} = \psi(x_{it,}\, \hat{\beta})$$

Assume that Y, $\hat{Z}_1$ *and* $\hat{Z}_2$ are the matrices of vectors y_{it}, $\hat{z}_{it} I(k_{it} \geq \tau)$ *and* $\hat{z}_{it} I(k_{it} < \tau)$. Given any threshold values, we run the regression of Y on $\hat{Z}_1$ *and* $\hat{Z}_2$ by using the least squares method in order to generate the sum of the squared residuals $S(\tau)$. Therefore, the estimator of the threshold value τ is obtained by minimising the sum of squared errors.

$$\hat{\tau} = \min S(\tau) \tag{3-9}$$

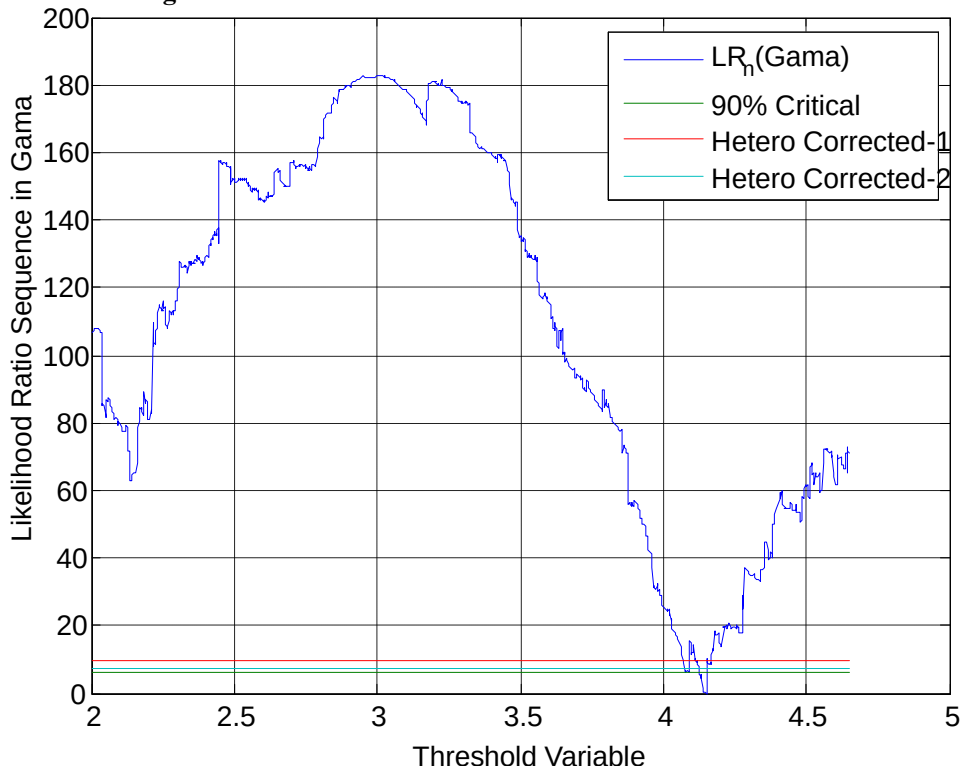
Figure 3-4 explicitly describes the threshold value (4.150256) at the point where the LR ratio strikes 0[33]. Following the implication illustrated by Caner and Hansen (2004) and Hansen (2000), the asymptotic confidence interval for the threshold value is robust to heteroskedasticity, set

[33] The result of the threshold model is obtained using the code of Matlab provided by Hansen (2000) and Caner and Hansen (2004). I should thanks for their sharing here.

confidence interval $= \{\tau : LR(\tau) \le \hat{\eta}^2 Criticalvalue\}$.

This is an asymptotically valid 90% confidence region, and the likelihood ratio of the threshold value approaches $\eta^2 C$ ($LR(\tau) \to \eta^2 C$), where C is the 90% of the distribution function of a random variable ξ[34]; $\eta^2 = 1$ in the case of homoskedasticity; otherwise we have to estimate η^2 in the case of heteroskedasticity. The points where $LR(\tau) \le Critical\ value$ are the points in the confidence region, and the critical value is presented in green (the lowest flat line) as displayed in Figure 3-4.

Figure 3-4 Confidence Interval Construction for Threshold



[34] The distribution function of ξ is $p(\xi \le x) = (1 - \exp(-x/2))^2$, which has an inverse: $Criticalvalue = -2\log(1-\sqrt{1-\alpha})$, following Hansen (2000).

3.3.2 Two Stage Least Squares (2SLS)

Wooldridge (2002, p83) suggests that Two Stage Least Squares (2SLS) should be used, given that there is a correlation between unobservable errors and explanatory variables, so instrumental variables (IV) should be included in the estimations to eliminate endogeneity. Thus, the third step of the threshold model with instrument variables presented by Caner and Hansen (2004) is to estimate the slopes by using 2SLS.

Recalling Eq. 3-5, $y_{it} = \theta_1' z_{it} I(k_{it} \le \tau) + \theta_2' z_{it} I(k_{it} > \tau) + \varepsilon_{it}$

where,

z_{it} is a *m*-vector and $z_i = (z_{1i}, z_{2i})$. Assume that the explanatory variable $z_{2i} \in x_i$ is exogenous and z_{1i} is correlated with the error term ε_{it}, thus, it is endogenous.

Set $\hat{X}_1 \; and \; \hat{X}_2$ as the matrices of vectors $x_i' I(k_{it} \le \tau), and \; x_i' I(k_{it} > \tau)$, and $\hat{Z}_1 \; and \; \hat{Z}_2$ are the matrices of vectors $z_{1i}' I(k_{it} \le \tau), and \; z_{1i}' I(k_{it} > \tau)$. Therefore, the vectors of the estimators $\hat{\theta}_1 \; and \; \hat{\theta}_2$ of 2SLS are shown below:

$$\hat{\theta}_1 = (\hat{Z}_1' \hat{X}_1 (\hat{X}_1' \hat{X}_1)^{-1} \hat{X}_1' \hat{Z}_1)^{-1} (\hat{Z}_1' \hat{X}_1 (\hat{X}_1' \hat{X}_1)^{-1} \hat{X}_1' Y)$$

$$\hat{\theta}_2 = (\hat{Z}_2' \hat{X}_2 (\hat{X}_2' \hat{X}_2)^{-1} \hat{X}_2' \hat{Z}_2)^{-1} (\hat{Z}_2' \hat{X}_2 (\hat{X}_2' \hat{X}_2)^{-1} \hat{X}_2' Y)$$

In order to identify the endogeneity of variables, the Hausman specification test (Wooldridge, 2002, p118) has to be employed. The original form of the Hausman statistic (HS) is shown as follow:

$$HS = (\hat{\beta}_{2SLS} - \hat{\beta}_{OLS})'[\hat{Var}(\hat{\beta}_{2SLS}) - \hat{Var}(\hat{\beta}_{OLS})]^{-1}(\hat{\beta}_{2SLS} - \hat{\beta}_{OLS}) \quad (3\text{-}10)$$

where,

$\hat{\beta}_{2SLS}$ represents the vector of coefficients in terms of 2SLS estimation.

$\hat{\beta}_{OLS}$ represents the vector of coefficients in terms of OLS estimation.

$\hat{Var}\hat{\beta}_{2SLS}$ represents the variance-covariance matrix of 2SLS coefficients.

$\hat{Var}\hat{\beta}_{OLS}$ represents the variance-covariance matrix of OLS coefficients.

The Hausman statistic is distributed asymptotically as Chi-square.

The null hypothesis is that the tested variables are exogenous and not correlated with the error term, the 2SLS and OLS estimators should differ only by sampling error, and in other words, OLS is preferred. The alterative hypothesis is that the difference between the 2SLS and OLS estimators is statistically significant, then, 2SLS can be employed. The Hausman test result is shown in Table 3-1.

Table 3-1 Results of the Hausman Specific Test

	(b) 2SLS	(B) OLS	(b-B) Difference	SQRT (diag (V_b-V_B)
TA	-0.025	-0.0017	-0.024	0.0438
Equity	-0.008	0.0036	-0.011	0.0027
Loandep	0.012	0.0005	0.011	0.0018
Interassets	0.193	-0.543	0.736	0.149
GDP	-0.089	-0.084	-0.004	.
Inter rate	-0.014	-0.011	-0.003	.
Test: H0: difference in coefficients not systematic Chi2(6)=(b-B)'[(V_b-V_B)^(-1)](b-B)=44.65 Prob>Chi2=0.000				

The result shows that the value of the Chi-square test statistic is large (44.65), rejecting the null hypothesis of OLS at the 1% significant level given that *p*-value is 0. The Hausman test suggests that the difference between the OLS estimators and 2SLS estimators is systemically significant, thus, 2SLS is preferred in this study.

We also have to check whether the instruments are appropriate in the 2SLS estimation by using the correlation test. Therefore, the reduced-form equation in the first stage of 2SLS should be used. Recalling the reduced form Eq. 3-6,

$$z_{it} = \psi(x_{it,}\, \beta) + u_{it}$$

where,

z_{it} is a m-vector of endogenous variables.

x_{it} is a k-vector of exogenous variables (k≥m) and can be IVs.

β is a vector of coefficients.

The null hypothesis of the test is that $H_0 : \hat{\beta} = 0$ suggesting that IV is not valid. The alternative hypothesis is that $H_1 : \hat{\beta} \neq 0$. If the coefficient of IV is significantly different from 0, which indicates that the instruments are correlated with the endogenous variables. Therefore, a valid IV is identified.

In this study, we use one-year lagged values of endogenous variables as IVs, since bank behaviour is continuous and banks rebalance their assets and liabilities using previous performance. The one-year lagged values of the equity ratio and loan-deposit ratio are

predetermined at t-1; as a result, these variables are not correlated with the current error term. Thus, they can be employed as IVs to estimate the endogenous variables. The correlation test is used to test the validity of IVs, and the result is shown in Table 3-2.

Table 3-2 Results of the Correlation Test

IVs	t-statistics	P>|t|
Equity ratio(-1)	109.66	0.000
Loandep ratio (-1)	161.73	0.000

As suggested by t-statistics, all coefficients of IVs are significantly different from 0 at the 1% significant level in the reduced form equations. The *P*-value shows that we can reject the null hypothesis of insignificance. Thus, one-year lagged values of the equity ratio and loan-deposit ratio as IVs are valid in the 2SLS estimations.

3.3.3 Diagnostic Test for Heteroskedasticity

We then attempt to detect whether heteroskedasticity exists or not. We use a modified Wald test for groupwise heteroskedasticity in a fixed effect model (Hausman statistics suggest that the fixed effect model is preferred, see Tables 3-5 and 3-6). Based on Greene (2000, p598), this programme in Stata tests the null hypothesis that there is no heteroskedasticity. The results of this test are indicated in Tables 3-5 and 3-6, and are more than the critical value at the 1% significant level, given that *p*-value is 0, suggesting that errors in the fixed effect model are heteroskedastic impacting the consistency of estimators. Thus, we should find ways to correct standard errors in the estimations. Normally, the solution is to make standard errors robust to heteroskedasticity. We use a programme in Stata[35] to construct "robust" standard errors given the presence of endogeneity, so *t*-statistics reported in Tables 3-5 and 3-6 are

[35] Schaffer, M.E. (2010). Stata module to perform extended IV/2SLS, GMM and AC/HAC, LIML. See http://idears.repec.org/c/boc/bocode/s456501.html

corrected for heteroskedasticity.

3.4 Data and Variables

3.4.1 Data

Macro-level data are chosen from IMF and Datastream, and bank-level data are chosen from Bureau Van Dijk Bankscope. Because of data availability in Bankscope, the study period is restricted from 1996 to 2008. We use the banks with data disclosure of interbank assets and loan loss provision during the study period, as these two variables are the main concern in this study[36]. The sample countries follow Chapter 2. Therefore, 357 banks are chosen from Bankscope, of which 103 are from the US, 28 are from the UK, 76 are from Germany; 71 are from France, 47 are from Denmark, 14 are from Belgium and 18 are from Austria. Unbalanced sample data with different numbers of time observations for each bank are used in this study. All data are measured in million US dollar[37] and ratios are presented as percentages.

3.4.2 Variables

This study mainly aims to test the three assumptions mentioned above: first, large banks are more likely to be associated with higher risk under TBTF given their key position in the economy; second, considering TBTF, large banks have less incentive to monitor borrowers, so an increase in interbank assets generates a higher level of bank risk; third, an increase in equities or deposits provides additional protection, particularly for small banks. In addition, in order to capture the time specific effect, such as the development of financial systems and improvement in the capacity of bank activities over time, year dummy variables are used in this estimation. Therefore, recalling Eq.3-8, considering time dummy variables, the estimated

[36] Actually, we use the banks with at least three subsequent years of time series data for bank-level variables in order to make the results to be reliable and stable.

[37] All values are automatically exchanged to US dollar by Bankscope according to the exchange rate on each closing day.

function is shown as below:

$$LLP_{i,t,j} = \begin{cases} \alpha_1 TA_{i,j,t} + \alpha_2 Equity_{i,j,t} + \alpha_3 Loandep_{i,j,t} + \alpha_4 InterL_{i,j,t} + \alpha_5 GDP_{j,t} + \alpha_6 InterR_{j,t} \\ + \sum_{\omega=1}^{12} \beta_\omega D\_Year_\eta (TA \geq \tau) \\ \lambda_1 TA_{i,j,t} + \lambda_2 Equity_{i,j,t} + \lambda_3 Loandep_{i,j,t} + \lambda_4 InterL_{i,j,t} + \lambda_5 GDP_{j,t} + \lambda_6 InterR_{j,t} \\ + \sum_{\omega=1}^{12} \delta_\omega D\_Year_\eta (TA < \tau) \end{cases}$$

(3-11)

where,

LLP is the ratio of loan loss provision to total assets and is presented as a percentage. As a proxy of credit risk, LLP has been used in previous banking estimations. For example, Keeton and Morris (1987, 1988) and Demirguc-Kunt and Huizinga (1998) investigate the link between bank risk-taking and macro-economic shocks using loan loss provision as a measure of credit risk; Fisher *et al*. (2000) find that a higher loan loss provision indicates an increase in bank risk-taking. In the context of the interbank market, Dinger and Hagen (2009) use loan loss provision as an indicator of the riskiness of bank behaviour to evaluate the effect of interbank borrowing on the credit risk level. Data are chosen from Bankscope.

TA is the bank size and is defined as the log-transformation of total bank assets. TA is a threshold through which we can estimate the differences in bank activities and risk-taking between large and small banks based on the implications of Dinger and Hagen (2005), considering the effect of TBTF suggested by Freixas et al. (2000). We expect a positive coefficient for large banks under TBTF. Data are chosen from Bankscope.

Loandep is a ratio defined as total bank loans to total deposits and is presented as a percentage. The loan-deposit ratio is considered as an endogenous variable, since banks can change their portfolios according to the risk level. In this work, I use the loan-deposit ratio to reflect liquidity risk: an increase in the loan-deposit ratio suggests higher liquidity risk-taking (Lepetit et al., 2008b), which might force banks to become involved in interbank markets. Moreover, a large loan base might require higher loan loss provision as a buffer against potential risk-taking due to adverse selection. Thus, the sign is expected to be positive. Data are chosen from Bankscope.

Equity is defined as the equity to total bank assets and is presented as a percentage, which reflects the effect of capital regulation on bank risk. A higher equity ratio indicates that shareholders have more incentive to monitor bank activities, which in turn reduces the level of risk-taking (Dinger and Hagen, 2005). Thus, the expected sign is to be negative. Data are chosen from Bankscope.

InterL is defined by interbank assets[38] to total bank assets and is presented as a percentage. Dinger and Hagen (2005) indicate that large banks are willing to monitor borrowing banks, which may reduce the risk level of interbank assets; however, considering the moral hazard problem in large banks under TBTF (Freixas et al., 2000), we may argue that large banks have less incentive to screening banks as they participate in potential bail-outs. Thus, the sign is expected to be positive for large banks. Data are chosen from Bankscope.

This model also investigates the effect of the macro-economy on bank risk-taking in the

[38] According to Bankscope's definition, the interbank asset is defined as money lent to other banks but excluding the reserves to central bank.

context of interbank markets based on Elsinger *et al*. (2002, 2006a, b). GDP is the GDP growth rate. It is calculated by dividing the value in the year *t* minus the value in the year *t-1* by the value in the year *t-1*. Data are chosen from international financial statistics (IMF). Good macro-economic performance decreases the default probability of borrowers, which in turn reduces the risk level of interbank lending. Thus, the expected sign is to be negative.

InterR is the interbank rate (3-month)[39] and reflects the scenario of the money market. Lending banks require higher interest rates for fear that borrowers will be unable to repay in a downturn. A higher interbank rate indicates a higher level of potential risk-taking in interbank markets, which in turn increases the marginal costs of lending (Panetta et al., 2004). Thus, the expected sign is to be positive. Data are chosen from Datastream.

D_Year is year dummy variables to capture the time specific effect of changes in bank structure and financial system, such as the development of technology and improvement in the capacity of bank activities over time, taking 2002 as a base.

τ is a threshold value in terms of bank size.

η is the year dummy variables from 1997 to 2008.

i=1,…357 is the number of banks

j=1,…7 is the number of individual countries.

t=1997,…2008 is the year.

The description of variables is shown in Table 3-3.

[39] Due to data availability, we use federal funds rates as a replacement for the US. Data source: Datastream.

Table 3-4 shows the statistics based on each country during the study period. Regarding median values, a higher level of LLP is presented in Germany, Austria and Denmark, which might be more concerned about bank risk-taking. A higher level of interbank asset holding is shown in the UK, which may result from a considerable and active UK interbank market associated with large amounts of interbank trading; and the US economy displays fast growth compared with European countries, indicated by the higher value of the GDP growth rate. Table 3-5 shows the matrices of correlation among bank-level variables.

Table 3-3 A Description of Variables

Variables	symbols	Descriptions	Sources
Dependent variable	LLP	The ratio of loan loss provisions to total assets and presented as percentages	Bankscope; Author's own calculation
Bank-level variables	TA	Log transformed and as a threshold variable	Bankscope; Author's own calculation
	InterL	The ratio of interbank assets to total assets and presented as percentages	Bankscope; Author's own calculation
	LoanDep	The ratio of total loans to total deposits and presented as percentages, which is suspected as an endogenous variable.	Bankscope ; Author's own calculation
	Equity	The ratio of equity to total assets and presented as percentages, which is suspected as an endogenous variable.	Bankscope; Author's own calculation
Macro-level variables	GDP	GDP growth rate is calculated by dividing the value in year t minus the value in year t-1 by the value in the year t-1.	IMF; Author's own calculation
	InterR	Interbank rate (3-month); Federal funds rate for the US	Datastream
Seasonal effects	D_Year	It is equal to 1 in a certain year, 0 otherwise.	Author's own calculation

Table 3-4 The Statistics for Sample Countries

The U.S.	Minimum	Median	Mean	Maximum
LLP	-1.338	0.218	0.441	8.082
INTERL	0.000	1.600	46.00	59.00
TA	2.279	3.830	3.967	6.120
Equity	1.560	8.640	9.665	42.220
Loandep	0.080	84.94	91.17	137.770
GDP	3.168	5.666	5.291	8.150
INTERR	1.000	4.687	3.768	6.437
The U.K.				
LLP	-4.444	0.009	0.183	4.625
INTERL	0.000	28.20	34.50	94.80
TA	1.423	3.080	3.034	4.731
Equity	0.000	9.370	12.56	95.780
Loandep	0.000	83.360	84.722	135.24
GDP	4.247	5.545	5.348	6.608
INTERR	3.812	5.968	5.502	7.312
GERMANY				
LLP	-1.570	0.458	0.605	8.456
INTERL	0.000	10.40	13.80	89.90
TA	0.397	2.578	2.653	4.780
Equity	0.460	5.260	6.878	66.700
Loandep	0.000	61.200	57.52	91.060
GDP	0.961	2.176	2.315	4.367
INTERR	2.145	3.521	3.481	5.039
FRANCE				
LLP	-2.547	0.200	0.377	5.980
INTERL	0.000	19.20	23.80	87.00
TA	1.454	3.127	3.163	5.100
Equity	-0.230	6.860	9.381	97.44
Loandep	0.000	190.410	156.69	266.890
GDP	2.736	3.872	3.846	5.366
INTERR	2.145	3.521	3.512	5.039
DENMARK				
LLP	-6.015	0.427	0.466	4.750
INTERL	0.000	8.100	11.10	84.10
TA	0.001	2.469	2.515	4.700
Equity	0.000	13.220	14.06	80.950
Loandep	0.000	66.550	77.17	130.650
GDP	2.036	4.284	4.184	6.633
INTERR	2.202	3.85	3.858	5.910
BELGIUM				
LLP	-14.046	0.040	0.033	2.051
INTERL	0.800	13.50	22.90	96.70
TA	1.650	3.024	3.138	4.522
Equity	0.000	5.680	9.027	59.070
Loandep	0.000	32.000	34.66	78.510
GDP	1.740	4.310	3.975	5.779
INTERR	2.174	3.54	3.543	5.108
AUSTRIA				
LLP	-0.507	0.404	0.541	5.458
INTERL	2.500	14.20	19.50	88.80
TA	1.668	2.704	2.711	3.790
Equity	3.390	6.010	7.231	37.240
Loandep	3.370	61.460	55.82	92.110
GDP	1.848	3.734	3.77	5.263

Table 3-4 Cont.

INTERR	2.145	3.521	3.509	5.039
Overall sample				
LLP	-14.046	0.262	0.434	8.456
INTERL	0.000	9.000	15.07	96.70
LASSET	0.001	3.063	3.168	6.120
Equity	-0.230	7.680	9.672	97.440
Loandep	0.000	79.17	83.30	266.89
GDP	0.969	4.310	4.100	8.150
INTERR	1.00	4.086	3.782	7.312

Notes: LLP: the ratio of loan loss provision to total assets; GDP: GDP growth rate; INTERL: the ratio of interbank lending assets to total assets; TA: a log-transformation of bank assets; Equity: the ratio of equity to total assets; Loandep: the ratio of loans to total deposits; INTERR: interbank rate (3-month) and federal funds rate for the US; the ratio is presented by percentages.

Table 3-5 The Matrices of Correlation among Bank-level Variables

	LLP	InterL	TA	Equity	Loandep
LLP	1.000				
InterL	0.106	1.000			
TA	-0.045	0.126	1.000		
Equity	0.008	0.038	-0.160	1.000	
Loandep	0.073	-0.595	0.054	-0.153	1.000

Note: LLP: the ratio of loan loss provision to total assets; INTERL: the ratio of interbank lending assets to total assets; TA: a log-transformation of bank assets; Equity: the ratio of equity to total assets; Loandep: the ratio of loans to total deposits.

3.5 Results and Analyses of Estimations

3.5.1 Basic Model

The empirical results, according to Eq.3-11, are presented in Table 3-6, which suggest significant differences between these two cases depending on the threshold parameter of bank size (4.150256). One such difference is the relationship between the bank risk level and interbank assets. We find a positive and significant coefficient in the group with large sized banks. This implies that interbank lending only matters for large banks, given a multiple money centre bank market structure, where large banks as money centre banks connected with other banks, non-financial institutions and governments are usually lending banks. A positive effect of interbank lending on risk-taking follows the assumption that large lending banks have less incentive to monitor borrowing banks, which leads to a higher level risk of interbank assets considering the effect of TBTF suggested by Freixas et al. (2000). The other possibility based on the theoretical work of Dinger and Hagen (2005) is that if the monitoring costs are higher than the difference in the repayment between “good” and “bad” borrowers, lending banks are not willing to monitor borrowers, which may increase the risk level of interbank assets.

As regards the effect of bank size, a positive and significant coefficient of bank size is found in the group where bank size is over the threshold, whereas a negative coefficient is found in the sample where bank size is less than the threshold. These indicate a U-shaped relationship between bank size and bank risk, suggesting that bank risk decreases and then increases as bank size goes beyond a certain level (4.150256). This result supports the assumption that given a multiple money centre bank market, large banks are associated with higher risk-taking by participating in a potential bail-out from CB, which is the consequence of moral hazard

from TBTF, as suggested by Freixas et al. (2000) and Tirole and Rochet (1996), and this may imply that bank regulation does not work for big banks. In addition, this positive result for bank size is consistent with the positive result of interbank lending for big banks, since TBTF reduces the lending bank's incentives to screen borrowers and even encourages them to become involved in risky assets. This U-shaped link also follows the results of the basic regression (see Appendix 4) which implies a nonlinear relationship between bank size and bank risk-taking.

The coefficients of the loan-deposit ratio are positive and significant in both of the empirical models, which support the assumption that banks which have more deposits and fewer investments are assumed to be more stable and less risky, as suggested by Dinger and Hagen (2005). Moreover, Lepetit et al. (2008b) point out that a higher loan-deposit ratio implies that banks with higher liquidity risk-taking might need to refinance through the interbank markets. This result also follows the empirical findings of Fisher et al. (2000) and Demirguc-Kunt and Huizinga (1998), that a large loan base increases risk level and deteriorates loan quality, as banks may lend to borrowers with bad credit by charging higher interest rates (adverse selection). Thus, an increase in the amount of loans triggers a higher level of loan loss provision as a buffer against potential risk.

In terms of the equity ratio, a negative and significant coefficient is found in the small bank group, which supports the assumption that small banks with fewer equities are more likely to be associated with higher risk-taking (Dinger and Hagen, 2005). This is also consistent with the empirical findings of Dinger and Hagen (2009) and Clarke et al. (2003), which indicates that shareholders have more incentive to monitor bank activities on behalf of their interests

because of a lack of protection from CB for small banks; thus an increase in the equity ratio in small banks leads to lower risk-taking.

GDP growth is significant and negative in both cases, which indicates the cyclical impact of macro-economic growth on bank risk-taking. This result follows the suggestions of Wells (2004), Elsinger et al. (2006a, b), Upper (2007) and Dinger and Hagen (2009), that the risk level of interbank assets is highlighted particularly in a recession; thus banks increase loan loss provision as a buffer against shocks from the macro-economy. According to Demirguc-Kunt and Huizinga (1998), economic development can improve the efficiency of bank management, i.e., more information disclosure, to reduce bank risk-taking, therefore, in this respect, the better the macroeconomic growth, the lower the loan loss provision is required.

As regards the year dummy variables, generally, the level of risk-taking by large banks increased from 2006 to 2008, which is consistent with the scenario of the financial markets. Since large banks are potentially protected by the government when facing challenges, considering the "Greenspan put" and "Bernanke put" for example, where the US Federal Reserve lowered the short-term interest rate, and purchased bad debt and securities from banks in order to maintain public confidence towards the financial market and macro-economy. However, this is coupled with the consequence of moral hazard from TBTF. The risk level of small banks reduced over time, since small banks might specialise in traditional activities associated with lower risk-taking, but they have less opportunity to be involved in complex financial activities compared with large banks. Although product diversification can theoretically provide risk diversification, it is associated with higher

risk-taking due to inappropriate regulation and inefficient risk management, considering the recent financial crisis.

The significant dummy variables (after 2005) suggest the time specific effect on bank risk-taking: this leads us to divide the sample period into two sub-periods 1996-2005 and 2006-2008 (the formal test will be shown in the next section), since we are interested in the differences in the effect of bank activities in the run-up to the financial crisis and the financial crisis period itself. Therefore, we present extended empirical models with the threshold in terms of two sub-periods for large and small banks.

Table 3-6 Results of Basic Model

Dependent variable: Loan loss provision ratio	$TA \geq 4.150256$	$TA < 4.150256$
Interbank lending	1.147**	0.177
	[1.96]	[0.96]
Bank size	0.606***	-0.229***
	[2.86]	[-3.01]
Loandep ratio	0.034***	0.012***
	[3.46]	[3.55]
Equity ratio	0.007	-0.013***
	[0.30]	[-5.57]
GDP growth rate	-0.082**	-0.029**
	[-2.36]	[-2.07]
Interbank rate	0.392	0.177
	[0.69]	[0.96]
D_1997	0.368*	0.072
	[1.71]	[1.04]
D_1998	0.217	0.093
	[1.26]	[1.32]
D_1999	0.239	-0.127
	[1.27]	[-0.25]
D_2000	0.678***	0.095*
	[3.21]	[1.68]
D_2001	0.023	0.011
	[0.20]	[0.26]
D_2003	-0.199	-0.139***
	[-1.54]	[-2.92]
D_2004	-0.099	-0.196***
	[-0.61]	[-3.21]
D_2005	0.34	-0.274***
	[1.73]	[-4.46]
D_2006	0.492**	-0.304***
	[2.34]	[-4.34]
D_2007	0.666***	-0.382***
	[3.25]	[-3.40]
D_2008	0.788***	-0.082
	[3.42]	[-0.89]
No. of individual banks	60	326
Total observations	516	3753
Hausman test Chi2 (17)	37.13***	37.60***
Heteroskedasticity Chi2 (65)/(338)	3.7e+32***	8.6e+5***
R-square	0.34	0.06

Notes: TA: log-transformation of total bank assets, which is a threshold variable. It is used to divide the sample in two classes. 4.150256 is a threshold value of log bank total assets, so the original bank size in terms of this threshold is $14133.7 million. t-statistic is denoted in [] and corrected for heteroskedasticity. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively.

3.5.2 Extended Model with Interaction Variables

In order to present the evidence of splitting the estimated period into two sub-periods, we use the Chow test (1960). The null hypothesis is that the parameters are consistent over the two sub-periods; the alternative hypothesis assumes that the parameters are inconsistent, in other words, there is a break within the period. The *F*-statistic of the Chow test is set:

$$F = \frac{[SSE - (SSE_1 + SSE_2)]}{SSE_1 + SSE_2} / \frac{K}{N - 2K}$$

where,

K is the number of independent variables.

N is the number of total observations.

SSE is the sum of squared residual.

SSE_1 and SSE_2 are the sum of squared residual in sub-period 1 (1996-2005) and 2 (2006-2008), respectively.

For large banks, the F-value is 4.70, which is distributed as F(7, 528) with critical value 2.03. The F-statistic is large enough to reject the null hypothesis at the 5% significant level, hence this result cannot reject the break within the study period: 1996-2005 and 2006-2008. For small banks, the F-value is 9.12, which is more than the critical value (2.02) with the degree of freedom (7, 4079); thus, we also can divide the period: 1996-2005 and 2006-2008. To investigate the effect in these two sub-periods, recalling Eq.3-11, the extended model using interaction variables is shown as follows:

$$LLP_{i,t,j} = \begin{cases} \alpha_1 TA_{i,j,t} + \alpha_2 Equity_{i,j,t} + \alpha_3 Loandep_{i,j,t} + \alpha_4 InterL_{i,j,t} + \alpha_5 GDP_{j,t} + \alpha_6 InterR_{j,t} \\ + \sum_{\omega=1}^{12} \beta_\omega D\_Year_\eta + \sum_{\mu=1}^{6} \theta_\mu Interaction\_Vari_\mu (TA \geq \tau) \\ \lambda_1 TA_{i,j,t} + \lambda_2 Equity_{i,j,t} + \lambda_3 Loandep_{i,j,t} + \lambda_4 InterL_{i,j,t} + \lambda_5 GDP_{j,t} + \lambda_6 InterR_{j,t} \\ + \sum_{\omega=1}^{12} \delta_\omega D\_Year_\eta + \sum_{\mu=1}^{6} \kappa_\mu Interaction\_Vari_\mu (TA < \tau) \end{cases} \quad (3\text{-}12)$$

where,

η is the year from 1997 to 2008, taking 2002 as a basis.

μ is the number of independent variables including bank size, loan-deposit ratio, equity ratio, interbank lending, GDP growth rate and interbank rate.

i=1,…357 is the number of banks.

j=1,…7 is the number of individual countries.

Interaction_Vari is interaction variables in terms of six independent variables by considering two sub-periods (1996-2005 and 2006-2008). It is equal to the original values of independent variables multiplied by 1 in the later sub-period, 0 otherwise.

Table 3-7 shows the results of the two bank groups in terms of the two sub-periods. Panel A reveals the effect of independent variables up to 2005, and the results in the later period are shown in Panel B[40]. Regarding interbank lending, the result in Panel A is consistent with that in the basic model, while Panel B shows the positive and significant coefficients of interbank lending in both groups. A significant result in the small bank group supports the conjecture suggested by Rochet and Tirole (1996), who argue that small banks are specialized in

[40] The magnitude of the effect of independent variables in the later period should be calculated by the sum of the coefficients of the independent variables in Panel A and Panel B.

deposit-taking but have few opportunities to invest. As a result, through the interbank markets they lend to large banks, which are involved in more complex financial products demanding a higher level of liquidity, particularly in the later sub-period (during the financial crisis). Thus, in this framework, CB prefers to directly rescue problematic borrowing banks (large banks) under the policy of TBTF, which induces higher risk-taking by large banks; moreover, the coefficient of big banks is bigger than the small bank group (8.827 for large banks and 0.741 for small banks), suggesting that big banks are associated with higher risk-taking, so they hold more loan loss provision against potential higher risk. A positive coefficient of bank size in the large bank group also can support this argument. Both of these positive and significant results of interbank lending in the large and small bank groups may suggest a mix of two different interbank market structures[41] indicated by Rochet and Tirole (1996) and Freixas et al. (2000) in the later sub-period when numerous banks (large and small) need to refinance through the interbank markets. In addition, the magnitudes of the effect of interbank assets on risk-taking during the crisis period (8.827 for large banks and 0.741 for small banks) are greater than those in the earlier sub-period (4.304 for large banks and 0.173 for small banks). This result is consistent with the suggestions of Halsall et al. (2008), Wetherilt et al. (2009), and Acharya and Merrouche (2009), who argue that the instability of the financial system has a negative impact on the interbank market by increasing the default risk level of interbank assets, since problematic banks are unable to repay lending.

Regarding the equity ratio, Panels A and B show that negative and significant coefficients of equity ratio are found in small banks, which is consistent with the result of the basic model.

[41]Rochet and Tirole (1996) display an interbank market structure, where small banks are lenders as they are associated with higher liquidity assets due to specialising in deposit-taking. As reviewed before, Freixas et al. (2000) show a money centre banks market structure, where large banks usually are lenders. Thus, both large and small banks tend to be borrowers in a mixed interbank market structure during the crisis period.

This highlights the importance of monitoring from shareholders to reduce the risk-taking of small banks owing to the lack of protection from CB. An insignificant result in terms of large banks might suggest that shareholders have less incentive to monitor bank activities due to a potential bail-out provided by CB; thus, we may argue that TBTF generates a moral hazard problem that is not only related to bank managers pursuing higher interests, but also related to shareholders or even depositors having less incentive to screen banks. This might be a possible reason for the recent crisis, in that neither regulators nor shareholders paid much attention to the risk-taking of large banks and allowed them to become involved in risky activities.

As concerns the macro-level variables, a close link between bank risk-taking and the macro-economy is identified based on Panel A and Panel B. A positive and significant coefficient of interbank rate is indicated in two groups during the crisis period. According to Furfine (2001), interbank assets are large and uncollateralised, which imposes a higher risk level on lending banks. Thus, lending banks have to price interbank loans carefully against potential risk-taking. In addition, the magnitude of the effect of the interbank rate is higher in the later sub-period, which is consistent with the scenario of the financial crisis in 2007-08. This result can support the findings of Nys (2003), Panetta et al. (2004) and Banal-Estonol and Ottaviani (2007), who argue that the interbank rate as a measure of market risk is used to reflect the situation of the financial markets and the attitude of the lending banks towards risk-taking. Banks are reluctant to lend in the interbank market during a downturn for fear that borrowers will be unable to honour their obligations; as a consequence, lending banks charge a higher interbank rate, which implies that the prediction of bank performance in the future is to be pessimistic, and this in turn demands an increase in the amount of loan loss provision as

a buffer against potential risk-taking.

In summary, these results support the assumption of the significant effect of TBTF on large banks. Given a multiple money centre bank market structure, CB as LLR provides bail-out for the large bank associated with a liquidity problem, because of its key position in the economy, which increases the banks' incentives to be involved in risky activities as a consequence of TBTF. This may encourage all banks to enlarge their size in order to participate in bail-outs. The empirical results also supports the second assumption that an increase in deposits or equities implies that banks are more stable and less risky, particularly for small banks, suggesting that shareholders pay attention to small banks' risk level because of a lack of protection from CB; while for large banks, shareholders have less incentive in controlling for bank risk-taking because of the potential bail-out provided by CB. The results also support the third assumption that an increase in interbank lending is associated with higher risk for large banks, considering the effect of TBTF.

Table 3-7 Results of Extended Model

Dependent variable: Loan loss provision ratio			$TA \geq 4.150256$	$TA < 4.150256$
Panel A	Bank size		0.937**	-0.364***
			[2.46]	[-3.55]
	Interbank lending		4.304**	0.173
			[2.29]	[1.03]
	Loandep ratio		0.033***	0.011***
			[3.61]	[3.13]
	Equity ratio		-0.005	-0.016**
			[-0.15]	[-2.22]
	GDP growth rate		-0.093**	-0.023
			[-1.96]	[-1.48]
	Interbank rate		-0.05	-0.02
			[-0.88]	[-1.10]
Panel B	Interaction_size		0.162***	0.036
			[3.68]	[0.18]
	Interaction_interlending		4.523**	0.568***
			[2.45]	[3.46]
	Interaction_loandep		0.04**	-0.0004
			[2.71]	[0.16]
	Interaction_equity		0.011	-0.023**
			[0.45]	[-1.96]
	Interaction_GDP		-1.54**	-0.036
			[-2.53]	[-0.89]
	Interaction_rate		1.50**	0.096***
			[2.17]	[3.04]
Panel C	D_1997		-0.206	0.05
			[-0.91]	[0.65]
	D_1998		-0.252	0.069
			[-1.32]	[0.89]
	D_1999		-0.238	-0.028
			[-1.20]	[-0.49]
	D_2000		-0.015	0.052
			[-0.06]	[0.79]
	D_2001		-0.106	0.009
			[-0.85]	[0.19]
	D_2003		-0.085	-0.128**
			[-0.59]	[-2.57]
	D_2004		-0.075	-0.203***
			[-0.42]	[-3.17]
	D_2005		0.117	-0.282***
			[0.61]	[-4.50]
	D_2006		1.71*	-0.58
			[1.94]	[-1.60]
	D_2007		1.838**	-0.682**
			[2.04]	[-2.02]
	D_2008		1.75*	-0.444
			[1.89]	[-1.34]
	No. of individual banks		60	326
	Total observations		516	3753
	Hausman test Chi2		40.36***	61.06***
	Heteroskedasticity (65)/(338)	Chi2	2.6e+30***	1.1e+6***
	R-square		0.35	0.07

Notes: TA : log-transformation of total bank assets, which is a threshold variable. It is used to divide the sample into two classes. 4.150256 is a threshold value of log bank total assets, so the original bank size in terms of this threshold is $14133.7 million. . Interaction_Vari: the values

of independent variables in the later sub-period are multiplied by 1, 0 otherwise. t-statistic is denoted in [] and corrected for heteroskedasticity. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively.

3.6 Conclusions

Using data on individual banks of developed countries from 1996 to 2008, this chapter has estimated the role of the size effect in determining the bank risk level in the context of interbank markets, particularly for estimating the differences in banks' activities between the run-up to the recent financial crisis and during the financial crisis period. Basically, the size effect plays an important role in determining bank risk-taking, suggesting that hazardous bank activities under TBTF, and the magnitude of the effect of bank activities on bank risk-taking is larger during the crisis period compared with that in the run-up to the crisis.

This chapter firstly identifies a U-shaped relationship between bank size and bank risk by using the non-linear regression, then using a threshold model in terms of bank size, it identifies the first assumption that a large bank is associated with higher risk-taking due to TBTF, since the result of bank size in the large bank group is positive and significant, but negative and significant for small banks. The empirical result also supports the second assumption that an increase in equities highlights the importance of monitoring and reduces bank risk level, particularly for small banks; however, the results cannot support this argument for large banks, since shareholders have less incentive to monitor bank activities under TBTF. Therefore, we find that the moral hazard problem results not only from bank managers but also from shareholders or even depositors, so the lack of cooperative regulation including government, shareholders and depositors might be one reason of the recent financial crisis. This study also supports the third assumption that interbank assets are associated with higher

risk, since large banks are not willing to monitor borrowing banks; moreover, the result of interbank lending is positive and significant in both bank groups during the crisis period when numerous banks (large and small) need to refinance through the interbank market. Large banks are associated with higher risk-taking compared with small banks, so they hold more loan loss provision against potential higher risk. In addition, we find a close link between bank risk-taking and the economic growth rate. A positive and significant result of the interbank rate is found in both bank groups during the crisis when banks have to charge a higher rate as a risk premium. In summary, these results are consistent with the implication of TBTF (Freixas et al., 2000) in the context of the interbank market.

Although TBTF can maintain a stable financial system and build public confidence in the banking sector, it leads to a moral hazard problem in that all banks make an effort to enlarge in size and benefit from regulatory forbearance. This contributes to the fact that banks prefer holding risky assets with higher profits, while the higher risk-taking of these assets is expected to be absorbed by CB. In addition, considering the recent financial crisis, although the costs of big bank failure are high, funding for rescuing big banks is considerable. Thus, we believe that policymakers should measure the probable gains and losses prior to proposing policies relating to large banks.

CHAPTER 4

THE EFFECT OF CHANGES IN BANK BEHAVIOUR ON THE DETERMINANTS OF INTEREST MARGINS

4.1 Introduction

Interest margin is defined as the difference between interest income and expenses divided by total earning assets, and varies within and across countries (see Table 4-3). For example, the mean value across banks is 3.781% in the US over twice that in Switzerland (1.633%); the interest margin within countries, for example, the UK, ranges from a negative (-1.06%) to a positive value (13.7%). Many researchers are interested in the determinants of bank interest margins, applying the theoretical work proposed by Ho and Saunders (1981), which mainly analyses the effect of interest rate risk on interest margins considering a single banking function: intermediation. However, since the 1990s, bank strategy has moved away from traditional activities to non-traditional activities (product diversification), such as collateralised debt obligation (CDO) and credit default swap (CDS), associated with non-interest income. Such changes in bank behaviour may have an impact on interest income,

and further on interest margins[42]. In addition, most previous studies of interest margins have concentrated on the European financial market as a whole or the US before 2001, without considering fundamental differences in financial systems and market structures across countries, so the lessons drawn from the studies cannot be applicable in different countries. Therefore, we attempt to make a country-by-country study of the determinants of interest margins[43], given the significant changes in bank activities up to the recent financial crisis and bearing in mind the data on banks in the European and North American financial markets.

This chapter is organised as follows: Section 2 discusses previous studies into the determinants of bank interest margins. A series of theoretical works show the development of factors impacting on interest margins, in particular the multi-product model of Valverde and Fernandez (2007), and empirical estimations according to the theoretical models are also described. Section 3 shows the model specification, examining the determinants of interest margins. Section 4 presents the data and variables, and the results of the empirical analysis are reported in Section 5, with the last section concluding.

4.2 Literature Review on the Determinants of Interest Margins

As a standard model on the issue of the determinants of bank interest margins, Ho and Saunders (HS) (1981) explicitly illustrate the effect of volatilities of interest rates on interest margins.

In the HS model, there are three main objects: basic wealth (W), credit inventory (C) and

[42] Interest expenses also increase due to higher competition in traditional activity markets, so interest margins reduce. This is one reason why banks are likely to be involved in non-traditional activities.
[43] This heterogeneous assumption will be tested later.

money market position (M). The total value of the bank's portfolio (P) is defined:

$$P = \widetilde{W} + \widetilde{C} + M \tag{4-1}$$

$$\widetilde{W} = (1 + i_W)W_0 + W_0\widetilde{r}_W \tag{4-2}$$

$$\widetilde{C} = (1 + i_C)C_0 + C_0\widetilde{r}_C \tag{4-3}$$

$$M = (1 + i)M_0 \tag{4-4}$$

where,

i_W is the expected rate on bank wealth.

i_C is the expected rate on the credit inventory.

i is the expected rate on the money market position.

$\widetilde{r}_W$ and $\widetilde{r}_C$ have an impact on the expected rates and are random variables.

The prices of loans and deposits are reported, respectively:

$$P_L = P_0 - \tau_L \tag{4-5}$$

$$P_D = P_0 + \tau_D \tag{4-6}$$

where,

P_0 is the basic prices of loans and deposits and assume that they are equal.

τ_L and τ_D are the service fees for loans and deposits, respectively. The interest rate of loans rises, since an increase in the fee of service τ_L leads to a lower price of loans. Thus, a negative relationship between the interest rate and loan price is suggested. Similarly, for deposits, a negative link between the interest rate and deposit price is found. The interest

spread is defined as the sum of τ_L and τ_D. Therefore, the expected utility conditional on the optimal fee of loans and deposits is given:

$$E(U(\widetilde{P} \mid \tau_D^*, \tau_L^*)) = \gamma_{\tau D} E(U(\widetilde{P} \mid Deposit\ Transaction)) + \gamma_{\tau L} E(U(\widetilde{P} \mid Loan\ Transaction)) \tag{4-7}$$

where,

τ_D^* and τ_L^* are the optimal service fees for deposits and loans, respectively, that maximise the expected utility of the bank's portfolio.

γ_{τ_D} and γ_{τ_L} are the probabilities of new deposits and new loans made based on their respective prices. As a result, the expressions of these two probabilities are given:

$$\gamma_{\tau D} = \alpha - \beta \tau_D \tag{4-8}$$

$$\gamma_{\tau L} = \alpha - \beta \tau_L \tag{4-9}$$

Maximising the expected utility conditional on the optimal fees of loans and deposits by taking partial derivative with respect to τ_D and τ_L, respectively, the results are shown below:

$$\frac{\partial E(U)}{\partial \tau_D}(\widetilde{P} \quad \tau_D^* \tau_L^*) = 0 \tag{4-10}$$

$$\frac{\partial E(U)}{\partial \tau_L}(\widetilde{P} \quad \tau_D^* \tau_L^*) = 0 \tag{4-11}$$

Combining the results from Eq.4-10 and Eq.4-11, the interest spread is displayed:

$$S = \tau_L + \tau_D = \frac{\alpha}{\beta} + \frac{1}{2} r \sigma_C^2 T \qquad (4\text{-}12)$$

where,

S is interest spread.

α / β is a measure of bank risk neutral spread.

r is the coefficient of risk aversion.

σ_C^2 is the variance of interest rate.

T is the size of transactions.

The key result suggests that the attitude towards risk, the size of transactions, the market structure and the volatilities of interest rates are the main factors that determine interest margins. According to Eq.4-12, Ho and Saunders (1981) undertook an empirical work using data on 53 US banks from 1976 to 1979 (quarterly data) considering imperfections of financial institution, which are not explicitly indicated in the theoretical model but have an impact on margins. These imperfections include implicit interest payments (IR), the opportunity cost of holding required reserves (OR) and the default risk on loans (DP). After controlling for these factors, the estimated interest margin would be a "pure" margin, which is the same for all sample banks (but with a time variant). Moreover, the authors argue that market structure, the size of bank transactions and bank attitude towards risk might change insignificantly over 3 years at quarterly frequencies, so they do not take these into account.

Therefore, the empirical model for cross-section estimations[44] is shown as:

[44] HS (1981) used a two-step method to examine the determinants of interest margins; controlling for IR, OR and DP in the first step aims to obtain a pure margin, which can be used in the second step to investigate the effect of volatilities of interest rate on margins.

$$IM = C(IR, OR, DP) \quad (4\text{-}13)$$

$$C = (\sigma^2, \varepsilon)$$

where,

IM is interest margins measured by the ratio of the difference between interest income and interest expenses to earning assets.

C is a constant, which are all positive and significant in cross-section estimations over time. C is assumed as a "pure" interest margin after controlling for IR, OR and DP, which is the same for all banks but time variant (homogeneous assumption).

IR is defined as the difference between non-interest expense and non-interest revenue divided by earning assets. The coefficients are positive and significant for all estimations.

OR is defined as non-interest bearing reserve assets divided by earning assets and then multiplied by average Treasury bill rate. The coefficients are positive and significant in the third quarter of 1977, and the first and second quarters of 1978.

DP is defined as net loan charge-offs divided by earning assets. The coefficient is positive and significant in the second quarter of 1978.

The significant and positive coefficients of IR, OR and DP follow the expectations of the authors, who argue that these additional costs require higher interest margins to compensate.

σ^2 is a measure of volatilities of interest rate, which is defined as variances of weekly data on Treasury bill rates of 3 month, 1 year, 2 year, 3 year and 5 year maturities. Ho and Saunders (1981) find that only the coefficient of volatilities of interest rates over 1 year maturity is positive and significant, and this significant result follows the implication of the theoretical work suggesting that interest rate risk is one of the determinants of interest margins.

The HS model (Ho and Saunders, 1981) concentrates on interest rate risk to illustrate the determinants of bank interest margins considering traditional intermediation; moreover, Ho and Saunders' (1981) empirical work, given the homogeneous assumption[45] only tests the effect of volatilities of interest rate on "pure" margins after controlling for institutional imperfections. Saunders and Schumacher (2000) also empirically test the determinants of interest margins using data on six European countries and the US from 1988 to 1995 based on the HS model (1981). The authors take volatilities of interest rate and market structure into consideration after controlling for institutional imperfections. They use a two-step method to estimate the determinants of interest margins. The cross-section model in the first step is shown as follows:

$$IM = (C, IR, OR_1, DP_1) \tag{4-14}$$

where,

C is a constant, which is a pure interest margin after controlling for institutional imperfections that is used in the estimation of the second step.

OR_1 is defined as non-interest earning assets to total assets.

DP_1 is defined as capital requirement to total assets, which is a measure for credit risk exposure (instead of DP measure in the HS estimation), as banks have to meet minimum capital requirement against potential credit risk.

The positive and significant coefficients of IR, OR_1 and DP_1 follow the results of the HS estimation.

[45] HS assume that the sample banks have similar attitudes towards risk, size of transactions, market power and interest rate volatilities, so that banks obtain the same pure interest margins after controlling for institutional imperfections.

The second estimation is shown by using the coefficient of C as a pure interest margin:

$$C = (\gamma, \sigma^2, c\_dummy) \tag{4-15}$$

where,

γ is a constant used to measure the average effect of market structure on margins.

σ^2 is a measure of volatilities of interest rate. Short-term risk is defined as a standard deviation of weekly securities rates (3-month) and long-term risk is defined as a standard deviation of weekly securities rates (1-year).

c_dummy is a country dummy, taking Germany as a base, which is used to capture changes in market structure across countries.

The significant and positive coefficients of the long-term risk and short-term risk are consistent with the HS model. The large coefficient of the US dummy suggests that the US financial market is not competitive, perhaps because of restrictions on universal banking operations; while the French market is likely to be more competitive, considering the negative coefficient of the France dummy.

According to the HS model, using data on 286 US commercial banks, Angbazo (1997) also studies the determinants of interest margins considering control variables under the CAMEL rating system[46] from 1989 to 1993; therefore, the empirical model is shown as follows:

$$IM = (a, DR, \sigma^2, LR, IR, OR_1, DP_1, MGMT, BRANCH) \tag{4-16}$$

[46] CAMEL includes capital adequacy, asset quality, management efficiency, earnings performance and liquidity. Earnings performance is a measure of interest margins in the estimation.

where,

IM is a measure of interest margins reflecting earnings performance of banks and is defined as interest income to average earning assets.

a is a constant.

IR and OR_1 follow the previous work, controlling for institutional imperfections. The positive and significant coefficients are consistent with the implications of the HS model.

σ^2 is a measure of volatilities of interest rates defined as the ratio of net short-term positions to book values of total equity capital. Angbazo (1997) suggests that the net short position is the difference between total assets subject to re-pricing and total liabilities subject to re-pricing within one year. The negative and significant results suggest that an increase in net short positions subject to re-pricing reduces the exposure of interest rate risk so that banks demand a lower interest margin. Since Angbazo (1997) and HS (1981) use different measures of interest rate risk as reviewed above, in this study, a higher level of net short positions (a measure of interest rate volatilities) indicates lower interest rate risk and in turn reduces interest margins. Thus, it still follows the implications of the HS model.

DR is a measure of asset quality (default risk), which is defined as the ratio of net charge-offs to total loans.

LR is a measure of liquidity (liquidity risk), which is defined as liquidity assets to total assets.

DP_1 is a measure of capital adequacy, which is defined as core capital divided by total assets.

MGMT is a measure of bank management, which is defined as earning assets to total assets.

DR, LR, DP_1 and MGMT are control variables under the CAMEL rating system. The significant and positive coefficient of DR suggests that risky loans require higher interest margins as a default risk premium; a negative and significant coefficient of LR suggests that

banks with higher liquidity assets require lower liquidity risk premium. A positive and significant coefficient of DP_1 follows previous studies, suggesting that additional regulatory costs demand higher interest margins. A negative and significant coefficient of MGMT suggests that efficient bank management is associated with lower interest margins.

BRANCH is a dummy variable, and is equal to 1 if the bank is headquartered in a state where there are restrictions on branch expansion, 0 otherwise. Angbazo (1997) does not find a significant result for BRANCH.

In the robust estimation of this work, it is worth noting that Angbazo (1997) discusses the effect of off-balance-sheet items (OBSs) on interest margins. The empirical results show that most of the OBSs, such as loan commitments and options, are positively linked with interest margins, suggesting that an increase in OBSs requires a higher level of interest income to offset contingent risks. Angbazo (1997) also argues that banks with OBSs can benefit more than those with restricted traditional intermediation.

Given the employment of non-traditional activities by banks over the past 20 years, Valverde and Fernandez (VF) (2007), based on the HS model (1981) and Allen's (1988) theoretical model, developed a multi-product theoretical work to discuss formally the effect of product diversification on interest margins. In their model, assume that a bank portfolio includes bank loans, non-traditional activities (NTAs) related to fee income, and deposits. Recalling Eq.4-5 and 4-6: the price of NTAs is defined as:

$$P_N = P_o - \tau_N \tag{4-17}$$

where,

P_0 is the basic prices of NTAs, loans and deposits, assuming that they are equal.

τ_N is service fees of NTAs.

The VF model is a dynamic model as it considers information at the beginning and the end of the period to maximise bank utility. Recalling Eq.4-7, the expected utility conditional on the optimal fees of loans, deposits and NTAs is therefore modified and shown as follows:

$$E(U(\widetilde{P} \mid \tau_D^*, \tau_L^*, \tau_N^*)) = \gamma_{\tau D} E(U(\widetilde{P} \mid Deposit\ Transaction)) + \gamma_{\tau L} E(U(\widetilde{P} \mid Loan\ Transaction)) + \gamma_{\tau N} E(U(\widetilde{P} \mid NTA\ Transaction)) \quad (4\text{-}18)$$

where,

$\gamma_{\tau N}, \gamma_{\tau_D}$ and γ_{τ_L} are the probabilities of new NTAs, new deposits and new loans made based on their prices, respectively.

γ_{τ_D} is introduced above (see Eq. 4-8).

Recalling Eq.4-9, considering NTAs, γ_{τ_L} is modified by

$$\gamma_{\tau L} = \alpha - \beta\tau_L + \delta_N \tau_N \quad (4\text{-}19)$$

and,

$$\gamma_{\tau N} = \alpha - \beta\tau_N + \delta_L \tau_L \quad (4\text{-}20)$$

δ_N and δ_L are the cross-elasticities of the demand of non-traditional activities and loans, respectively.

Following the approach of the HS model, the results of maximising the expected utility

conditional on optimal fees of loans, deposits and NTAs by taking partial derivatives with respect to τ_N, τ_D and τ_L, respectively, are shown as follow:

$$\frac{\partial E(U)}{\partial \tau_N}(\widetilde{P} \mid \tau_D^*, \tau_L^*, \tau_N^*) = 0 \tag{4-21}$$

$$\frac{\partial E(U)}{\partial \tau_D}(\widetilde{P} \mid \tau_D^*, \tau_L^*, \tau_N^*) = 0 \tag{4-22}$$

$$\frac{\partial E(U)}{\partial \tau_L}(\widetilde{P} \mid \tau_D^*, \tau_L^*, \tau_N^*) = 0 \tag{4-23}$$

Combining the results above, the function of interest margins is shown as:

$$IM = \tau_L + \tau_D = \frac{\alpha}{\beta} + \frac{1}{2} r\sigma^2 T + \frac{1}{4\beta}[2\tau_N(\frac{\delta_N}{\delta_L} + 1) - r\sigma^2 T] \tag{4-24}$$

where,

τ_L and τ_D are the service fees for loans and deposits, respectively. The sum of these is the interest margin.

α / β is market power: a higher level of market power indicates that banks with monopoly power can increase profits by requiring higher rates.

r is the coefficient of risk aversion.

T is the size of bank transactions.

σ^2 is volatilities of interest rate.

The difference between the results of the HS model (1981) and VF model (2007) is indicated by the last term, which shows that non-traditional activities reduce interest income given that

$2b_N(\frac{\delta_N}{\delta_L}+1)-r\sigma_C^2T<0$, as banks concentrate on non-traditional activities associated with fee income, which squeeze out traditional activities, e.g., loans with interest income. This model explicitly considers the development of bank behaviour over the past 20 years and formally shows the effect of changes in bank behaviour on interest margins.

According to the VF model, at the same time the authors empirically examine the determinants of interest margins considering bank risk-taking, the size of bank transactions, NTAs and macroeconomic growth. They use data on European financial institutions from 1994-2001. Therefore, the estimation is shown as follows:

$$IM=(a,IM(-1),MP,DR,\sigma^2,LR,IR,DP_1,MGMT,LOAN,DEPO,OBSs,GDP,BMDummy) \quad (4\text{-}25)$$

where,

IM is interest margin, which is defined as the difference between the ratio of interest income to loans and ratio of interest expense to deposits.

IM(-1) is one-year lagged interest margins, since this model is a dynamic model considering information at the beginning and end of the period to maximise the bank's utility. A positive and significant coefficient supports the importance of previous information in determining bank interest margins.

MP is the Herfindal-Hirschman index as a measure of market power and is calculated from bank total assets in the national market, which is obtained from ECB reports of the EU banking structure. The authors cannot find a significant coefficient of MP, following the results of Cetorelli and Gambera (2002).

DR is defined as default loans to total loans, which is a measure of default risk, and a positive and significant coefficient follows the result of Angbazo (1997), suggesting higher interest margins as a default risk premium.

σ^2 is defined as the difference between interbank market rate (3-month) and deposit rates, which is a proxy of interest rate risk. A positive and significant coefficient follows the implications of the HS and VF models and is also consistent with previous empirical estimations.

LR is defined as liquidity assets to total assets, and is a proxy of liquidity risk. A positive and significant coefficient follows the result of Angbazo (1997) and Lepetit et al. (2008b), suggesting higher interest margins set as a liquidity risk premium.

DP is a measure of capital regulation defined as capital and bank reserve to total assets. This follows the previous empirical works, suggesting that higher interest margins can offset the regulatory costs of bank lending.

MGMT is a proxy of management efficiency, defined by operating costs to gross income. A positive and significant coefficient indicates that banks with higher operating costs demand higher interest margins.

LOAN is defined as loans to total assets. The negative and significant coefficient follows the argument of Valverde and Fernandez (2007), who suggest that specialisation in lending shows an efficient operation, which may reduce interest margins.

DEPO is defined as deposits to total liabilities. The positive and significant coefficient suggests that specialisation in deposits can reduce interest expenses (a decline in deposit rates), and further increase the difference between interest income and interest expenses (interest margins). The authors point out that banks can benefit from a stable customer relationship.

OBSs use the ratio of other earning assets to total assets to measure bank diversification. The

authors find that banks with a higher level of diversification reduce interest margins. Due to the higher fee income of non-traditional activities, this may squeeze out traditional activities and compensate the losses of traditional activities resulting from competitive markets.

GDP is a measure of macroeconomic growth and is defined as the GDP growth rate. The negative and significant coefficient supports the argument of Allen and Gale, (1994, 1996) and Berlin and Mester (1999), who point out the hypothesis of cross-sectional risk sharing*: "intermediaries transfer risk from certain agents to others"* by charging higher interest rates in a downturn. In the context of interest margins, other authors also investigate the effect of macro-variables on interest margins: using data on EU countries from 1986 to 1999, Abreu and Mendes (2001) show that there is a positive relationship between macroeconomic development and interest margins: in this respect, the better economic development, the higher the interest margins, reflecting bank profitability. Demirguc-Kunt and Huizinga (1999) present an empirical study on the relationship between interest margins and bank specific variables with economic growth using data on 7900 banks in multiple-countries from 1988 to 1995. They also find a positive relationship between economic growth (GDP) and interest margins.

BMDummy is a dummy variable representing banks in a banking-orientated or market-orientated financial system. It is equal to 1 for a bank-based market, 0 otherwise. Valverde and Fernandez (2007) find a negative and significant coefficient, suggesting that large interest margins are indicated in a banking-orientated system, since in this framework, banks highly depend on lending and deposit-taking (traditional intermediation) using a debt contract between banks and borrowers, while banks depend on capital market activities, i.e., pension funds, in a market-orientated financial system (Mullineux and Murinde, 2003, p13), where the authors cannot find a significant result on interest margins.

Regarding explanations for the effect of bank diversification on interest margins, another strand of the existing empirical work has illustrated cross-selling between traditional and non-traditional activities. Lepetit et al. (2008b), using data on 602 banks in Europe over 1996-2002 investigated the link between margins (or loan pricing) and the expansion of bank activities. They also find a negative impact of product diversification on margins following previous studies; however, they present an explanation that is different from the VF model. In order to absorb new customers for selling non-traditional products, banks use traditional activities, i.e., loans, by setting lower interest rates, and this in turn reduces interest income. It highlights cross-selling as banks can benefit from a long-run and stable customer relationship. This could be another possible interpretation for the negative effect of bank diversification on interest margins.

4.3 Model Specification

The model used to investigate empirically the determinants of interest margins is based on the VF model (2007). In this model, banks are assumed to be involved in both traditional activities, i.e., loans and deposits, and non-traditional activities, i.e., OBSs. The conclusion of the VF model (2007) suggests that not only interest rate risk but also an employment of non-traditional activities (product diversification) has an impact on interest margins, which is a main concern in this work. In addition, we have to consider the effect of bank specification, i.e., loans and deposits, on interest margins. Rogers and Sinkey (1999) and Siems and Clark (1997) argue that specialisation in bank activities can reduce operational costs and further require lower interest margins; however, VF (2007) argue that a decline in interest expenses resulting from activity specialisation, i.e., deposit-taking, may expand the spread between interest income and interest expenses and lead to higher interest margins.

In addition, the VF model (2007) is a dynamic theoretical model considering information at the beginning and end of the period to generate a conditional expectation of bank activities. Therefore, we may use the previous interest margin in this estimation. We also argue that using previous information on interest margins can reflect an adjusted cost of bank behaviour.

Besides bank diversification and specification, following HS (1981), Saunders and Schumacher (2000) and Angbazo (1997), we try to estimate the determinants of interest margins controlling for institutional imperfections: implicit interest payment (IR), where banks compete on deposit interest payment by either providing depositor subsidies or reducing service charges, which is additional operational costs requiring higher interest margins; non-interest bearing reserve (OR), where banks have to hold required reserve associated with opportunity costs, which also impact interest margins; and capital requirement (CR), where banks have to meet minimum capital requirement proposed by the Basel agreements to hold equity capital against potential risk-taking. In some cases, banks may endogenously choose more capital holding according to the risk level, even though this is coupled with additional costs. Consequently, this requires more interest margins to compensate.

In the context of interest margins, following Valverde and Fernandez (2003, 2007), Abreu and Mendes (2001) and Demirguc-Kunt and Huizinga (1999), we use macroeconomic factors that have an impact on interest margins in the estimation. A lower GDP growth may increase bank risk-taking, which requires higher interest margins as a risk premium. In addition, based on the VF model, we consider the effect of market structure, so concentration ratio is used in this study. A higher concentration ratio indicates a less competitive market, which leads to higher

interest rates and interest margins.

Moreover, both the VF and HS models suggest that the coefficients of risk-aversion influence margins. In our empirical study, banks are assumed to be risk-averse, which is also an assumption in VF (2007), Saunders and Schumacher (2000) and Angbazo (1997). Regarding the justification for this assumption, Angbazo (1997) suggests that in the HS model, banks are assumed to be involved in arbitrage, considering the coefficient of risk aversion, so that an interest margin exists. Moreover, the regulation towards issues, such as moral hazard and adverse selection would restrict bank risk-taking. The cost of bankruptcy is also a concern for banks, encouraging banks to be risk-averse. In addition, as this is a country-by-country study based on a heterogeneous assumption, we consider the time specific effect related to the change in financial system and regulation over time for each country, so year dummy variables are used in the estimation.

From the discussion above, the explanatory variables in this work could be arranged into four categories: Bank risk-taking (RISK), Institutional imperfections (INIM), Bank diversification and specification (BDS) and Macro-variables (MV). The reduced-form empirical model is shown as:

$$NIM=(NIM(-1), RISK, INIM, BDS, MV, T\_DUMMY) \quad (4\text{-}26)$$

where,

NIM (-1) is the one-year lagged value of interest margins.

RISK is the volatility of interest risk.

INIM includes implicit interest payment (IR), non-interest bearing reserve (OR) and capital requirement (CR).

BDS includes loans and deposits (specification or traditional activities), and other earning assets (product diversification).

MV includes the GDP growth rate and concentration ratio 5 (C5).

T_Dummy is year dummy variables to capture the change in market structure over time for each country.

Recalling Eq.4-26, the empirical model used in the estimation is therefore presented as follows:

$$\begin{aligned} NIM_{ijt} = {} & \alpha_0 NIM_{ijt-1} + \alpha_1 implipay_{ijt} + \alpha_2 oppoc_{ijt} + \alpha_3 (capit / tasset)_{ijt} \\ & + \beta_1 (loan / tasset)_{ijt} + \beta_2 (deposit / tliability)_{ijt} + \beta_3 (oearning / tearning)_{ijt} \\ & + \theta_1 \text{int} erestrisk_{jt} + \theta_2 GDP_{jt} + \theta_3 C5_{jt} + \eta D\_Year_t + \varepsilon_{ijt} \end{aligned} \tag{4-27}$$

where,

i is the number of individual banks.

j is the number of individual countries.

t is the years.

NIM_{ijt} is net interest margins.

NIM_{ijt-1} represents one-year lagged net interest margins and is an indicator of adjustment costs.

$implipay_{ijt}$ represents the implicit payment.

$oppoc_{ijt}$ represents the opportunity cost.

$(capit / tasset)_{ijt}$ represents the capital ratio.

$(loan / tasset)_{ijt}$ represents the loan ratio.

$(deposit / tliability)_{ijt}$ represents the deposit ratio.

$(oearning / tearning)_{ijt}$ represents the other earnings ratio.

$interstrisk_{jt}$ represents the interest rate volatilities (1-year).

GDP_{jt} represents the GDP growth rate.

C5 represents concentration ratio 5.

D_year represents year dummy variables. This is equal to 1 in a certain year, 0 otherwise.

ε_{ijt} represents an error term.

4.4 Data and Variables

4.4.1 Data Description

The sample countries are selected European countries including Canada, France, Germany, Switzerland and the UK, and the US[47] and the study period is from 1999 to 2008[48]. We use the banks with data disclosure of net interest margins and other earning assets during the study period, since these are the main concern in this study[49]. Annual bank-level data are

[47] France, Germany and the UK are representatives in the EU sharing the Single Market Programme, while Switzerland is a representative for outside the EU in Europe; Canada and the US are representatives for North America. VF (2007) point out "*there are still differences in regulation and financial framework even among EU countries",* which makes a country-by-country study reasonable or as a robustness check for pooling all countries in the context of interest margins study. Therefore, we provide a country-by-country study including European and North American countries in order to fill this gap; the heterogeneous assumption is tested in the next section.

[48] Most previous studies have considered the situation before 2001, while we chose a sample period from 1999 up to the recent global financial crisis in 2007-08, because the Gramm-Leach Bliley Act was proposed in 1999 in the US, which removed barriers between commercial banks and investment banks. Thus, we can consider the effect of changes in bank behaviour on interest margins in the US, and this can be compared with the European countries as they have been involved in non-interest activities since the 1980s.

[49] Actually, we use the banks with at least three subsequent years of time series data for all bank-level variables in order to make the results to be reliable and stable.

chosen from the Bureau VanDijk Bankscope database. Macro-level data are chosen from Datastream, International Financial Statistics of International Monetary Fund (IMF) and OECD Statistics. Thus, in total 514 banks are chosen, of which 27 are from Canada, 93 from France, 142 from Germany, 69 from Switzerland, 41 from the UK and 142 from the US. The sample used in this study is unbalanced panel data.

4.4.2 Definitions and Measurements of Variables

Net interest margins (NIM) is a dependent variable and directly obtained from the Bankscope database. It is defined as the difference between total interest income and total interest expenses divided by total earning assets. A higher interest margin is indicative of higher bank costs from either operations or risk-taking that need to be offset.

NIM (-1) is defined as one-year lagged net interest margins. As the VF model (2007) mentioned above is a dynamic model, we consider the one-year lagged value of interest margins to examine the determinants of interest margins. This can be used to reflect an adjusted cost of interest margins, which has an impact on bank decisions.

$$NIM = (1-\alpha)NIM_{-1} + \alpha NIM^{*} \qquad (4\text{-}28)$$

where,

NIM^{*} depends on other control variables in the regression.

$1-\alpha$ is the coefficient of NIM (-1), which reflects the adjusted costs of NIM.

$\alpha = 1$, $NIM = NIM^{*}$, which is a full adjustment of NIM.

$\alpha = 0$, $NIM = NIM_{-1}$, which indicates that there is no adjustment of NIM.

$0 < \alpha < 1$, $NIM = (1-\alpha)NIM_{-1} + \alpha NIM^{*}$, which is a partial adjustment of NIM.

Therefore, the expectation of the coefficient of NIM (-1) is between 0 and 1, which implies that there is a trade-off between adjusted costs and benefits.

(1) There are three control variables in the category of institutional imperfection (INIM), which has been found to affect bank interest margins (Ho and Saunders, 1981; Saunders and Schumacher, 2000; Angbazo, 1997).

Implicit payment is a proxy of fee payments (duty exemption) to depositors as banks have to compete on the deposit market. A large NIM is generated to cover this implicit payment as extra interest expenses. Thus, the expected sign of the implicit payment is positive. Following Saunders and Schumacher (2000) and Angbazo (1997), it is defined as the difference between total non-interest expenses and other operating income divided by total earning assets[50]. Data are chosen from the Bankscope database.

Opportunity cost is a measurement of the costs of holding non-interest bearing reserves. Although holding non-interest bearing reserves can be used against potential risk-taking, an increase in holding reserves requires a higher level of NIM to cover the opportunity costs of holding reserves. Thus, the expectation of the sign is positive. Following Saunders and Schumacher (2000) and Ho and Saunders (1981), it is defined as non-interest bearing over total earning assets. Data are chosen from the Bankscope database.

[50] Based on the Bankscope database, non-interest expense is defined as any operating costs of an administrative nature, and other operating income is defined as any income related to bank's core business. The implicit payment as extra interest expenses can be seen as the difference between them.

Capital ratio is obtained from the Bankscope database. It can be used to reduce credit risk. However, the higher the capital ratio, the more regulatory cost of holding capital is generated, and this in turn increases NIM to cover this cost (Saunders and Schumacher, 2000). Thus, the expectation of the sign is positive. In addition to the capital requirement, banks can endogenously choose the amount of capital holding as a buffer against credit risk (Valverde and Fernandez, 2007). Thus, the capital ratio might be considered as an endogenous variable in estimations.

(2) There are three variables in the category of bank diversification and specification (BDS).

Loan ratio is a proxy of proportional loans to total assets (loan size). Valverde and Fernandez (2007), Boot (2000) and Berlin and Mester (1999) suggest that banks specialised in lending may improve operational efficiency so that they can reduce loan rates, and this in turn lowers bank interest margins. Thus, the expectation of the sign is negative. The loan ratio is defined as loans divided by total bank assets. Data are obtained from the Bankscope database.

Deposit ratio is a proxy of proportional deposits to total liabilities (deposit size). Valverde and Fernandez (2007) point out that a large deposit ratio may increase the spread between interest income and interest expenses (a decline in interest expenses), since banks specialising in deposits benefit from a good and long-term relationship with depositors resulting in lower deposit rates. Thus, the sign is expected to be positive. The deposit ratio is defined as total customer deposits over total liabilities. Data are obtained from the Bankscope database.

Other earning asset ratio is a measure of bank diversification. Based on the Bankscope database, other earning assets consist of the trading of federal funds and securities, and interest bearing deposits other than loans, reflecting the diversification of bank activities.

Recalling Eq.4-25, the VF model (2007) implies that the introduction of non-traditional activities associated with non-interest income may squeeze out traditional activities towards interest income, and further reduce interest margins, as banks are inclined to operate more market-based services, due to higher competition in traditional activity markets. Regarding the negative effect of product diversification, Lepetit et al. (2008b) point out a conjecture that banks underprice loans to increase other activities, which highlights cross-selling among traditional and non-traditional activities, so that banks can benefit from long-term and stable customer relationships. Thus, the expected sign of the other earning asset ratio is negative. It is defined as other earning assets divided by total earning assets. Data are obtained from the Bankscope database.

(3) We consider the effect of volatilities of interest rate on interest margins based on the HS model (1981) and VF model (2007) in the category of RISK.

Interest rate risk: as suggested by Fernández and Valverde (2007), this is defined as the difference between interbank rates (one-year) and deposit interest rates[51]. According to the implications of the theoretical work, interest rate risk is expected to affect interest margins positively. Data are obtained from Datastream.

(4) Macro-variables include the GDP growth rate, following Valverde and Fernandez (2007), Abreu and Mendes (2001), Berlin and Mester (1999) and Demirguc-Kunt and Huizinga (1999), and concentration ratio 5 (C5), which is a measure of market structure.

GDP is the GDP growth rate. The value of the GDP growth rate in the year *t* is calculated by

[51] Saunders and Schumacher (2000) consider both short-term (three-month) interest rate risk and long-term (one-year) interest rate risk in the estimation but present two separate tests, due to the multicollinearity problem. We also tested the effect of long-term interest rate risk and short-term interest rate risk on NIM for each country, and we cannot find significant differences between these two estimations. Since we treat interest rate risk as a medium-term (one year) risk in this study, one-year data is used.

dividing the value in the year *t* minus the value in the year *t-1* by the value in the year *t-1*. Data are chosen from International Financial Statistics. In the context of interest margins, Allen and Gale (1994, 1996), Berlin and Mester (1999), and Allen and Santomero (2001) illustrate two possibilities of the effect of macroeconomic variables on interest margins: the first is the hypothesis that in cross-sectional risk-sharing, "*intermediaries transfer risk from certain agents to others*" by charging a higher interest rate in a downturn so that people who are risk-averse bear less risk-taking than people who like risk-taking; while during an upturn, a higher GDP growth rate is indicative of lower credit risk, thus banks would like to charge lower interest rates. Based on this argument, the expected sign of GDP is negative. Another possibility is the "intertemporal rate smoothing hypothesis", which suggests that banks charge a higher interest rate in an upturn, while banks require a lower rate using their liquidity base in a downturn; hence GDP is expected to be positively related to interest margins.

Concentration ratio 5 (C5) is defined as the sum of the market shares in terms of total bank assets, of the five largest banks in domestic financial markets. The data for European countries excluding Switzerland come from ECB statistics and the data of Switzerland and North American are based on OECD statistics[52]. With higher C5, lower competition level is found in financial markets; hence banks have more power to charge higher loan rates in order to obtain higher interest margins.

Time_D is year dummy variables to capture the specific effect of changes in financial system and regulation over time for each country. It is equal to 1 in a certain year, 0 otherwise. A description of the variables is given in Table 4-1.

[52] We calculate concentration ratio 5 based on the definition provided by ECB. The data of total bank assets of the domestic market is available at http://stats.oecd.org/index.aspx?

Table 4-1 A Description of Variables

Variables	Symbols	Descriptions	Sources
Dependent variable	NIM	It is defined as the difference between total interest income and total interest expenses divided by total earning assets.	Bankscope
Bank specific variables	NIM(-1)	One-year lagged NIM	Author's calculation
	Implicitpay	It is defined as the difference between total non-interest expenses and other operating incomes divided by total earning assets.	Bankscope Author's calculation
	Oppor.cost	It is defined as non-interest bearing to total earning assets.	Bankscope Author's calculation
	Cap. ratio	It is defined as total regulatory capital to total assets	Bankscope
	Loan ratio	It is defined as the ratio of total loans to total bank assets.	Bankscope Author's calculation
	Dep.ratio	It is defined as the deposits to total liabilities.	Bankscope Author's calculation
	Other ratio	It is defined as other earning assets to total bank assets.	Bankscope Author's calculation
Macro-level variables	Inter. risk	It is defined as the difference between the interbank rate (1-year) and deposit rates.	Datastream Author's calculation
	GDP	It is calculated by dividing the value in the year t minus the value in the year t-1 by the value in the year t-1.	IMF Author's calculation
	C5	It is defined as the sum of the market shares in terms of total bank assets, of five largest banks in domestic financial markets.	ECB; OECD statistics; Author's calculation
Seasonal effect	Time_D	Year dummy variables to capturing the time trend.	----

Table 4-2 provides a summary of the expectations of the signs of the explanatory variables and gives possible rationales for these expectations.

Table 4-2 Expected Signs of Empirical Explanatory Variables

Independent variables	Predicted signal	Rationale	References:
NIM(-1)	Positive	It belongs to (0,1) due to a trade-off between benefits and costs	VF theoretical model (2007)
Implicitly payment	Positive	Non-interest expense ↑ ⇨ Impli pay ↑ ⇨ NIM ↑	Empirical results of VF (2007) and HS (1981)
Opportunity cost	Positive	Non-interest bearing ↑ ⇨ Oppor ↑ ⇨ NIM ↑	Empirical results of VF (2007) and HS (1981)
Capital ratio	Positive	Capit ratio ↑ ⇨ cost of NIM ↑ ⇨ NIM ↑	Empirical results of VF (2007) and HS (1981)
Lending ratio	Negative	Operational costs ↓ ⇨ NIM ↓	Empirical results of VF (2007)
Deposit ratio	Positive	Interest expense ↓ ⇨ NIM ↑	Empirical results of VF (2007)
Other earning asset	Negative	Diversification ⇨non-interest income ↑ ⇨ NIM ↓	VF theoretical model (2007)
Interest rate risk	Positive	Volatility ↑ ⇨ Risk premium ↑ ⇨ NIM ↑	VF theoretical model (2007) and HS theoretical model (1981)
GDP	Negative or Positive	Cross-sectional risk sharing ⇨ NIM ↓ Intertemporal rate smoothing ⇨ NIM ↑	Empirical results of VF (2007), Berlin and Mester (1999), and Allen and Santomero (2001)
Concentration ratio 5	Positive	C5 ↑⇨ competition ↓ ⇨lending rates ↑ ⇨ Interest margins ↑	VF theoretical model (2007) and HS theoretical model (1981)

4.4.3 Statistics of Empirical Variables

Table 4-3 gives a summary of the statistics for the variables in terms of individual countries. We are interested in the value of NIM. Valverde and Fernandez (2007) and Mullineux and Murinde (2003, p13) suggest that banks in the US, the UK and Switzerland are operated in a market-based financial system, where banks mainly depend on capital market activities, i.e., pension funds. Canadian, French and German financial markets are indicative of a bank-based market, where banks rely highly on intermediary activities. Thus, regarding the mean value of NIM, higher interest margins are indicated in France, Canada and Germany, but are lower in the UK and Switzerland. The US banks are associated with large interest margins: faster economic growth might contribute to this result.

Table 4-3 Statistics of Variables for Sample Countries

Canada	minimum	mean	maximum
NIM	-4.080	2.217	13.350
Implicit paym	-4.003	0.606	4.247
Oppor.cost	0.015	0.436	4.422
Capital ratio	0.002	0.055	0.237
Loan ratio	0.042	0.593	0.978
Deposit ratio	0.076	0.708	0.951
Other earning	0.423	0.910	0.994
GDP	2.964	5.769	9.947
France			
NIM	-8.520	2.477	11.310
Implicit paym	-25.684	0.985	16.817
Oppor.cost	0.000	0.244	11.824
Capital ratio	-0.135	0.096	0.923
Loan ratio	0.000	0.587	0.988
Deposit ratio	0.000	0.731	0.992
Other earning	0.000	0.368	1
GDP	2.779	3.945	5.366
Germany			
NIM	0.000	2.471	8.730
Implicit paym	-7.991	1.438	35.905
Oppor.cost	0.000	2.670	77.918
Capital ratio	0.009	0.058	0.620
Loan ratio	0.000	0.565	0.994
Deposit ratio	0.068	0.857	0.981
Other earning	0.000	0.408	1
GDP	0.010	0.142	0.351

Table 4-3 Cont.

Switzerland			
NIM	0.000	1.633	9.100
Implicit paym	-25.884	-0.469	10.663
Oppor.cost	-0.010	0.116	3.798
Capital ratio	0.019	0.117	0.601
Loan ratio	0.000	0.574	0.972
Deposit ratio	0.065	0.714	0.970
Other earning	0.004	0.381	1
GDP	0.799	3.222	6.222
The UK			
NIM	-1.060	2.033	13.700
Implicit paym	-57.463	-0.248	6.193
Oppor.cost	0.004	0.494	5.460
Capital ratio	0.005	0.115	0.940
Loan ratio	0.004	0.445	0.962
Deposit ratio	0.001	0.684	0.995
Other earning	0.000	0.534	0.994
GDP	3.148	5.093	5.968
The US			
NIM	-0.240	3.781	16.640
Implicit paym	-22.142	1.661	54.166
Oppor.cost	0.000	0.085	8.193
Capital ratio	-0.028	0.088	1
Loan ratio	0.000	0.667	0.983
Deposit ratio	0.000	0.674	0.929
Other earning	0.000	0.271	1
GDP	2.584	5.109	6.511

Notes: NIM: net interest margins; Implicit paym: implicit payment; Oppor.cost: opportunity cost; Other earning: other earning asset ratio.

Table 4-4 shows the results of mean test for each bank-level variable between sample countries. All the values of *F*-statistic are more than the critical value at the 1% significant level and *p*-values are 0, which suggest that we should reject the null hypothesis: means are the same across countries being compared. Therefore, in this study, we may provide a country-by-country estimation in order to capture the differences in bank activities across countries.

Table 4-4 Mean Test for Each Bank-level Variable between Sample Countries

	NIM	Implicit paym	Oppor. cost	Capital ratio	Loan ratio	Deposit ratio	Other earning
F-Statistic (5)	214.05***	62.32***	133***	288***	26.20***	73.64***	33.04***
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: F-statistic is used for a multiple comparison of means, and the results are obtained by using the code "oneway-ANOVA" in Stata. The null hypothesis: means are the same across the groups (more than two) being compared. *** indicates significance at the 1% level for the test. NIM: net interest margins; Implicit paym: implicit payment; Oppor.cost: opportunity cost; Other earning: other earning asset ratio.

Table 4-5 presents the concentration ratio from 1999 to 2008 across countries. Less competitive markets are indicated in Canada and Switzerland, suggesting that several large banks dominate the financial markets. Owing to national consolidation, the concentration ratio in the US increased over time in order to take advantage of the economies of scale. Table 4-6 shows the matrices of correlation among bank-level variables.

Table 4-5 Concentration Ratio 5

Canada	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
CR5	0.6204	0.6213	0.6269	0.6251	0.6139	0.6001	0.6081	0.6238	0.6228	0.6543
France										
CR5	0.3833	0.3857	0.3693	0.3733	0.3102	0.3128	0.3313	0.3179	0.3346	0.3673
Germany										
CR5	0.1902	0.2022	0.2024	0.2010	0.210	0.2144	0.210	0.2133	0.2124	0.2202
Switzerland										
CR5	0.6712	0.6677	0.6605	0.6579	0.6449	0.6498	0.6451	0.6352	0.6293	0.6689
The UK										
CR5	0.2751	0.2817	0.2857	0.2961	0.3275	0.3450	0.3625	0.3594	0.4070	0.3649
The US										
CR5	0.2714	0.3192	0.3263	0.3400	0.3445	0.3828	0.3595	0.3537	0.3581	0.3906

Notes: Data for European countries excluding Switzerland come from ECB statistics; the data of Switzerland and North American are based on OECD statistics and we calculated concentration ratio 5 for these countries following the definition provided by ECB in order to make them to be consistent. The data of total bank assets of the domestic market is available at http://stats.oecd.org/index.aspx?

Table 4-6 The Matrices of Correlation among Bank-level Variables

	NIM	Implicit paym	Oppor.cost	Capital ratio	Loan ratio	Deposit ratio	Other earning
NIM	1.000						
Implicit paym	0.204	1.000					
Oppor.cost	0.010	0.013	1.000				
Capital ratio	0.229	-0.15	0.103	1.000			
Loan ratio	0.198	0.079	0.011	0.154	1.000		
Deposit ratio	-0.002	0.172	0.010	-0.132	0.220	1.000	
Other earning	0.024	-0.035	-0.029	-0.173	-0.225	-0.360	1.000

Notes: NIM: net interest margins; Implicit paym: implicit payment; Oppor.cost: opportunity cost; Other earning: other earning asset ratio.

4.5 Results and Analyses of Estimations

4.5.1 Diagnostic Tests for Endogeneity and Heteroskedasicity

As banks may endogenously determine the composition of a bank portfolio and adjust capital structure according to the risk-taking level, loan ratio, other earning assets ratio and capital ratio are suspected endogenous variables in this estimation.

Wooldridge (2002) suggests that the method of two-stage least squares (2SLS)[53] can be used to eliminate endogeneity. First, we have to test the endogeneity of the suspected variables (capital ratio, loan ratio and other earning assets ratio) using the Hausman specification test introduced in Chapter 3. The null hypothesis of Hausman specification test is that the tested variables are exogenous and not correlated with the error term; the 2SLS and OLS estimators should differ only by sampling error; in other words, OLS is preferred. The alternative hypothesis is that the difference between the 2SLS and the OLS estimators[54] is statistically significant; then 2SLS can be employed.

Second, we should present the test of the validity of IV. The null hypothesis of this test is that $H_0 : \beta = 0$, where β is the coefficient of IV in the reduced-form equation: the endogenous variables are regressed on all independent variables including both exogenous variables and IV. If the coefficient of IV is equal to zero, this suggests that IV is not valid. If the coefficient of IV is significantly different from zero, this suggests that IV is correlated with the endogenous variables and this in turn can identify the validity of IV.

[53] The methodologies of the 2SLS, Hausman specification test and the test of the validity of IVs were introduced in Chapter 3.

[54] Recalling Eq.3-10 in Chapter 3, the Hausman specific test statistic has been given: $HS = (\hat{\beta}_{2SLS} - \hat{\beta}_{OLS})'[\hat{Var}(\hat{\beta}_{2SLS}) - \hat{Var}(\hat{\beta}_{OLS})]^{-1}(\hat{\beta}_{2SLS} - \hat{\beta}_{OLS})$

Tables 4-7, 4-8 and 4-9 show the results of the Hausman specification test and correlation test regarding capital ratio, loan ratio and other earning asset ratio, respectively. We run the Hausman specification test for the endogeneity of independent variables and check whether it is correct to use one-year lagged endogenous variables as IVs in the 2SLS estimations. The test results of Table 4-7 provide the evidence of the endogeneity of the capital ratio for all countries, since the value of Chi-square is more than the critical value; we reject the null hypothesis of OLS estimation at the 1% significant level given that p-value is 0. The Hausman specification test indicates that there are significant differences between the 2SLS and OLS estimators; therefore, the 2SLS model is preferred for all sample countries. In addition, the results of the correlation tests are significant at the 1% significant level in terms of reduced-form equations, which suggest that one-year lagged capital ratio is a valid IV. Similarly, we find the endogeneity of the loan ratio in Canada, France, and the UK, and the endogeneity of other earning assets is indicated in France, Germany, Switzerland and the US as shown in Tables 4-8 and 4-9. These results implicitly reflect differences in banking operations across countries, which require a robustness test to identify whether all countries can be pooled as a whole. We will present this test in the next section. The results of the correlation test suggest that one-year lagged values of these endogenous variables can be used as a valid IV in the estimations.

Table 4-7 Results of Two Tests (Capital)

	Test 1 Endogeneity	*Test 2 Correlation*
Countries	Hausman specification test	Instrumental Variable
Canada	42.95***	0.933***
	(0.00)	[27.013]
France	293.54***	0.907***
	(0.00)	[63.343]
Germany	403.74***	0.913***
	(0.00)	[184.238]
Switzerland	157.44***	0.628***
	(0.00)	[28.352]
The UK	136.61***	0.734***
	(0.00)	[23.546]
The US	246.96***	0.557***
	(0.00)	[38.120]

Notes: *** denotes significant at the 1% significance level; () indicates p-value of Hausman specification test; [] denotes t-statistics.

Table 4-8 Results of Two Tests (Loan)

	Test 1 Endogeneity	*Test 2 Correlation*
Countries	Hausman specification test	Instrumental Variable
Canada	21.59***	0.383***
	(0.01)	[9.82]
France	216***	0.811***
	(0.00)	[40.06]
Germany	7.0	---
	(0.51)	
Switzerland	2.59	---
	(0.97)	
The UK	142***	0.382***
	(0.00)	[12.30]
The US	13.3	---
	(0.11)	

Notes: ***, **,* denote significant at the 1%, 5% and 10% significance level; () indicates p-value of Hausman specification test; [] denotes t-statistics.

Table 4-9 Results of Two Tests (Other earning asset)

	Test 1 Endogeneity	*Test 2 Correlation*
Countries	Hausman specification test	Instrumental Variable
Canada	7.75	---
	(0.96)	
France	115***	0.109***
	(0.00)	[9.84]
Germany	77.80***	0.001*
	(0.00)	[1.88]
Switzerland	75.01***	0.01**
	(0.00)	[2.65]
The UK	5.84	---
	(0.66)	
The US	34.74***	0.02***
	(0.01)	[5.41]

Notes: ***, **, * denote significant at the 1%, 5% and 10% significance level; () indicates p-value of the Hausman specification test; [] denotes t-statistics.

We then try to identify whether heteroskedasticity exists. We use a modified Wald test for groupwise heteroskedasticity in Stata in terms of a fixed effect model (Hausman statistics suggest that the fixed-effect model is preferred, see Table 4-10). Based on Greene (2000, p598), this programme tests the null hypothesis that there is no heteroskedasticity. The results of this test are indicated in Table 4-10, which suggest that the errors in the fixed effect model are heteroskedastic. The solution for errors with heteroskedasticity was introduced in Chapter 3. Using a programme in Stata, t-statistics reported in Table 4-10 are corrected for heteroskedasticity.

4.5.2 Results and Analyses of Evaluations for Individual Countries

Table 4-10 shows the results of the estimations for six individual countries. The Chi-square value of the Hausman test suggests that we can reject the random effect model at the 1% significant level, so the fixed effect model is preferred in this study. According to the Valverde and Fernandez' (2007) dynamic theoretical model, using one-year lagged values of interest margins reflects the previous information in determining current bank behaviour, which can be used to maximise banks' utility.

The coefficients of the one-year lagged values of NIM are positive and significant for all sample countries, indicating the importance of previous information, and the coefficients are between 0 and 1, suggesting a partial adjustment of interest margins, so there is a trade-off between adjusted costs and returns.

Regarding three variables in the category of institutional imperfection (INIM), the coefficients of the implicit payment (fee proxy) are positive and significant in the estimations for Canada and France. Banks have to compete on deposit markets, so they would like to pay implicit interest to eliminate charging service fees. Saunders and Schumacher (2000) also show a relative higher fee payment in France from 1988 until 1995 compared with other European countries and the US. Thus, higher implicit payment to depositors demands higher interest margins to offset it. The coefficients of the opportunity cost are positive and significant in the tests on Switzerland, France the UK and the US. The non-interest-bearing reserve requirement increases the economic costs of holding reserves. Thus, banks raise NIM to compensate for this. We find that the coefficients of the capital ratio are positive and significant in all estimations. A positive coefficient indicates that, although holding more capital can be used against potential risk-taking, it is costly because of taxes and regulation on bank lending, which in turn increases NIM to offset these. The positive and significant coefficients of these variables controlling for institutional imperfections are consistent with the findings of Angbazo (1997), Saunders and Schumacher (2000), and Fernandez and Valverde (2007).

Regarding the explanatory variables in bank specification and diversification (BDS), the coefficient of the loan ratio is negative and significant in the tests on France,

Switzerland and the UK: the result is consistent with the findings of Petersen and Rajan (1995), Berlin and Mester (1999), Rogers and Sinkey (1999, 2000), Boot (2000) and Valverde and Fernandez (2007). They claim that a higher level of loans reduces the value of NIM, as banks with lending specialisation can provide efficient information and reduce the operating costs, leading to a lower loan rate. Thus an increase in lending would decrease interest margins. The coefficients of the deposit ratio are positive and significant in the tests of France, Germany, Switzerland and the UK. Banks specialising in deposits can benefit from a stable customers relationship, which decreases interest expenses (a decline in deposit rates) and hence augments the spread between interest income and interest expenses (interest margins). We are more concerned with the effect of bank diversification on interest margins. A negative and significant coefficient is found in the tests for Switzerland, Canada, the UK and the US, which is consistent with the implications of the theoretical work of Fernandez and Valverde (2007). Other earning assets are a substitute for loans to obtain higher fee income given a fixed amount of total funds for banks to operate. The development of financial market allows banks to be involved in product diversification. This significant change in bank behaviour has a negative impact on traditional activities towards interest income. In addition, this result can be explained by the conjecture that banks decrease loan rates in order to increase the amount of non-traditional products (cross-selling)[55], as banks can benefit from long-term and stable customer relationships (Lepetit *et al*., 2008b). The insignificant coefficients of product diversification in Germany and France might suggest that German and French banks operated in a bank-based market, where banks highly depend on traditional intermediation (Valverde and Fernandez, 2007; Mullineux and Murinde, 2003, p13).

[55] The effect of cross-selling between traditional and non-traditional activities was found in Chapter 2.

In terms of RISK, a positive and significant coefficient of interest rate volatilities is found in the tests for France, Switzerland, Germany, the UK and the US, which supports the implications of the dealership model suggested by Ho and Saunders (1981) and Fernandez and Valverde (2007), who point out that the interest margin is determined by interest rate volatilities. Even though the banking market is highly competitive, an increase in interest rate volatilities generates a higher level of NIM as the price for providing loan and deposit services, as long as banks are risk-averse and associated with uncertain transaction size. Since previous studies in this context concentrate on either European countries as a whole or the US, in this study we tested the effect of interest rate risk on margins based on Canada, but we cannot find a significant coefficient of interest rate volatilities. One possible explanation is that, considering credit rationing, interest margins could be less responsive to the change in interest rate (Angbazo, 1997).

Regarding GDP as a measure of the macro-economy, a negative and significant parameter of the GDP growth rate can be identified in the tests on the US, Switzerland and Germany. According to the views of Allen and Gale (1994, 1996), Berlin and Mester (1999), and Allen and Santomero (2001), a negative result is consistent with the hypothesis of cross-sectional risk-sharing in the context of interest margins, suggesting that banks can transfer risk from some agents to others by charging a higher interest rate in a downturn, so that the people bearing more risk are those who are least risk-averse. Thus, banks demand higher interest margins in a recession. Positive and significant coefficients of concentration ratio 5 are found in Germany, Switzerland and the US, suggesting that banks can increase lending rates in less

competitive markets, and this in turn raises interest margins. This result follows the findings of Lepetit et al. (2008b), while Valverde and Fernandez (2007) cannot find a significant effect of market structure on interest margins.

We use the year dummy variables to capture the time specific effect on interest margins for each country. A decline in interest margins before the recent crisis might be explained by the conjecture that banks underprice loans to raise non-traditional activities (Lepetit et al., 2008b). They argue that in order to absorb new customers, banks decrease the price of traditional activities, i.e., loans, so that they can sell non-traditional financial products to the same customer (cross-selling). Since 2005, sample countries suffered a decline in interest margins, particularly in 2007-08 (during the crisis), when the US and Canada suffered a more than 50% decline. This can be interpreted by Valverde and Fernandez (2007), who suggest that large involvement in product diversification could squeeze out traditional activities to obtain higher non-interest income, further affect interest income, although it might be coupled with higher risk-taking. Therefore, a negative effect of product diversification on interest margins can be found.

The previous studies in this context are based on pooled countries, and do not consider the differences in banking structure and regulation that might account for the inconsistent results on bank interest margins. In this chapter, we provide a country-by-country study to fill this gap, considering the effect of changes in bank behaviour up to the global financial crisis in 2008. However, to identify this heterogeneous assumption, we need to use a robustness test. First, we run the

regression with interaction variables[56] in terms of individual countries and then try to use the Wald test to check the coefficients of 50 interaction variables. The results of the estimation with interaction variables and Wald test are shown in Appendix 5. The null hypothesis of the Wald test is that the coefficients of the tested regressors are jointly equal to 0, suggesting that removing them from the model will not substantially reduce the fit of this model; the alternative hypothesis is that the coefficients are not jointly equal to 0. The Chi-square value of the Wald test is 9.28, given that p-value is 0, which suggests that we can reject the null hypothesis at the 1% significant level. Thus, we cannot pool all individual countries. This result shows significant differences in bank operations and financial systems among the sample countries. The response to shocks varies across countries, suggesting that a global standard regulation might not be able to take the country specific effect into account: in contrast, a single regime based on one region, i.e., ECB[57], might be more applicable for banking regulation and supervision.

[56] Interaction variable is defined as the specific independent variable multiplied by 1 for a certain country, 0 otherwise; this estimation includes 5 individual countries (the US is a base group) and 10 independent variables, thus 50 interaction variables are used in the estimation.

[57] Since the sample in this study is based on countries from the EU, outside the EU but in Europe and North America, the result of the Wald test indicates differences among these countries, which is reasonable; but this does not challenge the regional integration for banking regulation, i.e., ECB, which needs an investigation exclusively using more ECB members as a sample.

Table 4-10 Results of Estimations for Individual Countries

Dependent variable: NIM	Canada	France	Germany	Switzerland	The UK	The US
NIM (-1)	0.467***	0.382***	0.337***	0.383***	0.480***	0.348***
	[3.32]	[4.33]	[7.49]	[3.78]	[5.97]	[4.54]
INIM						
Implicit payment	0.590***	0.045**	0.0001	0.006	0.008	0.03
	[4.33]	[2.47]	[0.14]	[0.53]	[0.74]	[1.17]
Opport.cost	0.031	0.49**	-0.001	0.462*	0.225*	0.688**
	[0.19]	[2.36]	[-0.55]	[1.80]	[1.87]	[2.14]
Capit/asset	0.115**	6.38**	0.039***	5.938**	0.03**	0.091*
	[2.13]	[2.26]	[3.09]	[2.04]	[2.43]	[1.91]
BDS						
Lending	0.157	-0.582*	0.69	-1.89**	-0.545*	0.01
	[0.17]	[-1.88]	[1.05]	[-2.52]	[-1.76]	[0.02]
Deposits	0.751	1.59**	0.995***	2.632**	0.907*	0.414
	[0.77]	[2.06]	[3.17]	[2.29]	[1.95]	[1.06]
Other earning asset	-1.956**	-0.214	-0.011	-2.48***	-1.42***	-1.903***
	[-1.98]	[-0.70]	[-0.02]	[-3.47]	[-4.56]	[-5.71]
RISK						
Interest rate risk	-0.04	0.502**	0.188**	2.42*	0.19*	0.265**
	[-0.14]	[2.41]	[2.33]	[1.88]	[1.64]	[2.30]
MV						
GDP	-0.007	0.092	-0.122***	-0.61*	0.88	-0.755***
	[-0.18]	[0.84]	[-4.13]	[-1.81]	[0.54]	[-4.02]
C5	2.87	-2.47	1.79***	3.01***	-2.04	2.21*
	[0.25]	[-0.63]	[10.35]	[4.67]	[-0.67]	[1.82]
Dummy_Year						
D_2004	-0.344**	-0.244**	0.086**	0.002	-0.078	0.133
	[-2.36]	[-2.18]	[2.60]	[0.01]	[-0.89]	[0.78]
D_2005	-0.243*	-0.201**	-0.136***	0.027	-0.316*	0.022
	[-1.69]	[-1.98]	[-3.63]	[0.20]	[-1.91]	[0.13]

Table 4-10 Cont.

D_2006	-0.19	-0.249	0.057	-0.895***	0.038	-0.10
	[-1.10]	[-1.56]	[0.93]	[-4.20]	[0.42]	[-0.66]
D_2007	-0.182	-0.367**	0.007	-1.076***	-0.06	-0.253**
	[-1.20]	[-1.96]	[0.10]	[-3.80]	[-0.66]	[-2.49]
D_2008	-0.553***	-0.462***	-0.274***	-0.348***	-0.05	-0.569***
	[-3.80]	[-4.37]	[-7.42]	[-3.68]	[-0.18]	[-5.07]
Total Observations	208	805	1253	621	359	1177
R-Square	0.60	0.38	0.48	0.47	0.48	0.73
Heteroskedasticity Chi2	56981.94***	25366.01***	14722.52***	32376.31***	20471.68***	1.2e+05***
Hausman test Chi2	56.65***	273.069***	388.677***	171.533***	145.087***	209.587***

Notes: NIM: net interest margins=(total interest income-total interest expense)/total earning asset; NIM (-1): one lag of NIM; Implicit payment=(total non-interest expense-total non-interest income)/total earning asset; Opport.cost=(non-interest bearing/total earning asset)*treasury bill rate 3 month; Interest risk= difference between interbank rate (1-year) and interest rate of deposits; Lending=loan/total asset; Deposits=total customer deposits/total liability; Other earning asset ratio=other earning asset/total earning asset; Capit ratio: capital ratio; GDP: GDP growth rate. C5: concentration ratio 5.Year Dummy Variables: if in a specific year, the value is equal to 1, 0 otherwise. ***, ** and * denotes significant at the 1%, 5% and 10% significant level, respectively. t statistics are denoted in [] and corrected for heteroskedasticity.

4.6 Conclusions

This chapter investigated the effect of changes in bank behaviour on interest margins based on the Valverde and Fernandez's (2007) model. Controlling for institutional imperfections, interest margins were reduced by the introduction of non-traditional activities associated with higher fee income, which squeezes out traditional activities, hence reducing bank interest income. Negative coefficients of year dummy variables, particularly during the recent financial crisis, can also offer evidence that those banks with higher product diversification are indicative of lower interest margins. This negative result of product diversification can also support the argument of Lepetit et al. (2008b), who suggest that in order to absorb new customers, banks lower the interest rate of traditional activities, i.e., loans, so that they can sell non-traditional financial products to the customers (cross-selling); hence, interest income resulting from loans is reduced. As regards traditional activities, banks which specialised in lending reduce lending interest rates, this in turn lowers interest margins; and banks which specialised in deposit-taking can benefit from a stable customer relationship; this in turn reduces interest expenses and increases interest margins. In addition, this study finds a positive and significant effect of interest rate risk on interest margins, following the HS and VF models. Although banks in developed countries have been experiencing significant changes in bank behaviour, they still suffer traditional interest rate risk, which has an impact on interest margins. Regarding macro-variables, higher interest margins are found in less competitive markets (higher C5), as banks have more power to require higher interest rates.

This chapter contributes to providing a country-by-country study in the context of interest margins considering the differences in bank structures and financial systems among countries, and this heterogeneous assumption is identified by the robustness test. The effect of changes

in bank behaviour (product diversification) on interest margins is likely to be significant in a market-based financial market, such as Switzerland, the US and the UK. However, this is insignificant in a bank-based financial market, such as France and Germany, where banks are inclined to operate traditional intermediation. This result follows the implications of the VF theoretical model (2007). The results of the robustness test find differences in financial system and regulation, which suggest that a global standard regulation might not be able to take into account different responses to shocks across countries; in contrast, a regional single regime, i.e., ECB, might be more efficient.

CHAPTER 5

THE LESSONS FROM BANK FAILURE RUNNING UP TO A FINANCIAL CRISIS

5.1 Introduction

Recently, many economists (see Barrell *et al*., 2010; Reinhart and Rogoff, 2008) have paid more attention to banking crises because of the great losses from the recent crisis. They have used country-level data to investigate the reasons for banking crises and suggest that bank regulation, e.g., capital requirement, and macroeconomic variables, e.g., GDP, house prices, the stock index and current account balance, play an important role in determining banking crises. They have also summarised the banking crises across the main developed countries. During the past two decades, crises have occured at least once for most industrial countries, particularly the US and the UK, which have already experienced two and four crises, respectively. However, few studies have concentrated on individual bank failure in the context of the banking crisis in 2007-08, when initially major bank failures (e.g. Northern Rock, Bear Stearns, Lehman Brothers and Merrill Lynch) spread to other financial institutions as a banking panic: this in turn led to a serious banking crisis in the developed countries of Europe

and the US. Both bank managers and policy-makers are now taking an interest in the issue of why some banks fail while others do not, in order to protect individual banks from bankruptcy and maintain a stable financial system. Therefore, identifying the reasons for bank failure is the first step towards understanding the mechanism of banking crises in the developed countries. We have investigated the effects of non-traditional activities, interbank lending, and risk-taking on bank performance in the previous chapters. In this chapter, we attempt to combine these bank-level variables with macro-level variables as candidates to examine the causes of bank failure up to the recent financial crisis.

First, we are more concerned with the effect of changes in bank behaviour, such as the introduction of non-traditional banking activities (product diversification), on bank performance, particularly in the recent banking crisis. Although earlier empirical evidence (see Borio-Filosa, 1994; Litan, 1994; Saunders and Walter, 1994; Stiroh, 2004; Stiroh and Rumble, 2006; Baele et al., 2007; Calmes and Theoret, 2010) reviewed in Chapter 2 on the extent of bank diversification may vary, they find that the diversification associated with a risky product line, i.e., the complicated bundling of obligations, has a significant negative effect on bank performance.

Second, the shortage of liquidity assets is another concern. Dewatripont and Tirole (1994, p64) suggest that an illiquidity problem is actually a solvency problem. Banks with sufficient liquid assets are likely to be safe, especially in a downturn, when liquidity assets can be used against a bank run. Banks with a liquidity shortage can borrow from the interbank market, where lenders may make a prudent estimation of the potential risk level of problematic banks. Demirguc-Kunt and Huizinga (2009) find that interbank lending in both the US and Europe

was static by October, 2008, owing to a pessimistic attitude towards bank performance.

Third, bank performance is pro-cyclical with the macro-economy, this has been suggested in many earlier studies (see Gonzalez-Hermosillo, 1999; Demirguc-Kunt and Detragiache, 1998, 2000; Ergungor and Thomson, 2005; Davis and Karim, 2008; Reinhart and Rogoff, 2008). They argue that the banking crisis preceded economic recession, and therefore, can be predicted by economic indicators, such as housing prices. During the last decade, the real estate market has had a substantial impact on bank performance, particularly the complicated financial products related to sub-prime loans in the US, such as mortgage based securities (MBS) and collateralised debt obligation (CDO): the return on these assets depends on housing prices. When the price started to decrease, the US financial crisis also started.

Fourth, the recent financial crisis highlighted the importance of regulation of the banking sector. However, inappropriate regulation may distort banking activities and force banks to engage in risky trading (see Koehn and Santomero, 1980; Kim and Santomero, 1988; Rochet, 1992; Blum and Hellwig, 1995). They imply that, given capital regulation, banks tend to be involved in more risky assets associated with higher profits to offset regulatory costs, which may increase the probability of bank failure. Thus, based on the discussion above, we may argue that bank diversification, liquidity, capital regulation and macro-shocks determine the probability of bank failure.

The rest of this chapter is organized as follows: a literature review is introduced in Section 2; the econometric methodology and model specification are discussed in Section 3; and the empirical results are presented in Section 4. The conclusions are summarised in the last

section.

5.2 Literature Review

5.2.1 Theoretical Model of Bank Failure

Gonzalez-Hermosillo (GH) (1999) presents a framework of bank distress, explicitly suggesting the effects of profitability, capital adequacy and liquidity on the probability of bank failure. In this model, assume that a bank is associated with assets, including currency and risky earning assets and liabilities, including deposits and capital. The function of the probability of bank failure is shown:

$$F_z = F(d, y, c) \tag{5-1}$$

where,

F_z is the probability of bank failure.

d is deposit flows.

y is net asset income.

c is capital requirement according to a minimum capital requirement.

The net income on assets (bank profitability) function is shown below:

$$y = y(\beta^*(\tau) i_m, \alpha(\tau, i_m)) \tag{5-2}$$

where,

$\beta^*(\tau) i_m$ is a function of market risk.

τ denotes macro-variables, such as economic growth and housing prices.

$\beta*(\cdot)$ is determined by bank risk management, a higher $\beta*$ indicates highly cyclical bank portfolio; if $\beta*=0$ indicates that banks can hedge market risk.

i_m is market return, which is exogenous.

$\alpha(\tau, i_m)$ is a function of credit risk, which depends on macroeconomic shocks and market returns.

The deposit flow function is as shown below:

$$d = d(u,(F_Z \mid \rho*(\rho_{\max}, f, F_e), \varsigma)) \tag{5-3}$$

where,

u is the need of deposits for depositors, which is exogenous.

F_z is the expected probability of bank failure given the effective deposit guarantees $\rho*$.

$\rho*(\rho_{\max}, f, F_e)$ is a function of the maximum level of deposits that can be protected by a government, which depends on the maximum level of deposits ($\rho_{\max}$) that can be covered by deposit insurance funds (f, exogenous), and the expected probability (F_e) that there is a large number of bank failures in the financial system.

ς is used to generate an expectation function.

The structure of the GH model has two tiers: first, it explicitly presents the fact that profitability, liquidity and capital requirement have an impact on the probability of bank failure. Second, according to the function of bank income (Eq.5-2), it points out the

importance of fundamental risk-taking (credit risk and market risk) and the macro-economy in determining bank profitability, considering moral hazard. In this respect, the risk level might be increased, given a competitive market, where a bank engages in activities with higher risk-taking in order to make higher profits following "herding" behaviour, as they participate in potential protection from the government. Another case is that banks may suffer higher default risk as borrowers cannot (due to the macro-economic situation) or are not willing (but are able) to repay, which distorts banks' performance. In addition, according to the function of deposits (Eq.5-3), this model highlights the importance of liquidity management regarding deposit flows. If depositors cannot judge whether banks are "good" or "bad", or do not have confidence that the government holds sufficient funding for deposit insurance, this may generate a bank run, considering asymmetric information. Therefore, based on this model, we find that bank profitability, liquidity, capital holding, bank risk-taking and macro-economic shocks affect the probability of bank failure. However, given the development of bank behaviour over the past 20 years, we are more concerned with the effect of the diversification of bank activities on the probability of bank failure, particularly taking the recent financial crisis into consideration, as reviewed in Chapter 2. In addition, as this study aims to investigate individual bank failure, the difference between money centre banks[58] and small banks may influence bank performance. The effect of TBTF on large bank risk-taking has been found using the threshold model in Chapter 3 in the context of the interbank market, so in this chapter we would like to include bank size, taking TBTF into consideration, to see its effect on the probability of bank failure. Thus, we modify the GH model (1999) with additional variables controlling for the diversification of bank activities and size effect. We would expect to find the effect of these two additional variables on bank failure up to the

[58] These are usually large banks, and are connected with other banks, large non-financial firms and even governments, so their failure has a negative impact on the whole economy.

financial crisis 2007-08.

5.2.2 Indicator Description and Empirical Evidence

5.2.2.1 Capital Ratio Requirement

The modified GH model supports that bank diversification, capital adequacy, liquidity and macroeconomic shocks, as proposed in the first section of this chapter, are possible reasons for bank failure: we attempt to describe these indicators using empirical evidence in order to show their importance in determining bank failure. Regarding bank diversification, in Chapter 2, we introduced a theoretical and empirical review of the effect of bank diversification on bank profitability and presented a related empirical study, which shows a negative effect of non-traditional activities on bank profits.

Regarding capital requirement, in 1988, Basel Accord I set a solvency regulation to require a minimum capital requirement, and then Basel Accord II set a risk-based capital requirement as Pillar 1. This can be seen as an important indicator to predict bank failure. Goldstein and Turner (1996) imply that the capital requirement has a twofold function, not only as a buffer against potential bank risk but also to serve better governance. For example, shareholders pay more attention to the risk level of bank activities on behalf of their interests, so bank managers will not put banks at risk. Many countries, in particular developed countries, such as the US, have adopted the Basel Agreement, and even tend to hold higher capital ratios than the requirement. However, the efficiency of capital regulation has been questioned by many economists. Kim and Santomero (1988) and Rochet (1992) present an insight into the effect of capital regulation on the probability of bank failure using a portfolio model. The implications of these theoretical studies suggest that, in the context of the minimum capital requirement, banks prefer to employ assets associated with a higher level of risk-taking,

which in turn increases the probability of bank failure. Keeley and Furlong (1990), considering the limited liability of banks, used a mean-variance model to investigate the effect of capital regulation on the probability of bank failure. The negative effect of capital regulation on bank performance is also found, which is consistent with the Kim and Santomero's model (1988). Hellman *et al*. (2000) developed a theoretical model and argue that if the cost of capital holding increases, the bank charter value is reduced, which indicates a negative effect of capital regulation on bank performance.

Empirical studies on the effect of capital regulation have been explored. Using data on US banks, given a strict capital requirement, Grenadier and Hall (1996) suggest that banks have more incentive to shift activities with higher level risk towards safe activities. Nevertheless, Hovkimian and Kane (2000) find inefficient capital regulation when examining US banks from 1985 to 1994. The capital requirement has no impact on reducing large banks' incentives to take higher risk, as they can obtain subsidies of deposit insurance. Barth et al. (2001, 2004), using bank-level data on 107 countries from 1999 to 2004, suggest that the capital requirement cannot reduce the amount of non-performing loans, and find that private sector monitoring of banks is more effective than government supervision at improving bank performance.

5.2.2.2 Liquidity Ratio

As regards liquidity risk, according to Dewatripont and Tirole (1994, pp63-64), liquid assets play an important role in monitoring banking performance. For example, a solvent bank may face a problem of illiquidity. It has to borrow from other institutions through the interbank markets, which may generate a market's question about the solvency of the bank. Therefore, a liquidity shortage always tends to be a solvency problem. Demirguc-Kunt and Detragiache

(1998), Gonzalez-Hermosillo (1999), Logan (2000) and Heffernan (2003) empirically suggest that sufficient liquidity can protect banks against unexpected withdrawals, particularly in a downturn, and further lower the probability of bank failure.

5.2.2.3 Macroeconomic Indicators

As concerns macroeconomic shocks, Dewatripont and Tirole (1994, pp185-160) suggest that although the idiosyncratic shock and macroeconomic shock are not distinguished in Basel Accord I, the latter is highlighted in determining bank performance and the solvent ratio depends on the macroeconomic shock in the absence of an adjustment to the net worth of banks. With a higher level of macroeconomic shocks, intervention from regulation is imposed too often on the banking management; however, with a lower level of macro-level shocks, less regulation is imposed on bank operations, which results in many potential dangers for banks. Therefore, macroeconomic shocks have a significant impact on banking decisions, further influencing bank performance.

Empirical studies (see Hardy and Pazarbasioglu, 1999; Demirguc-Kunt and Detragiache, 1998, 1999; Kaminsky, 1999; Goldstein *et al*., 2000; Hagen and Ho, 2007) on the effect of macroeconomic shocks point out that economic indicators play an important role in determining the probability of bank failure. They believe that the economy affects the bank sector through two channels: the bank asset side and bank liability side. On the one hand, bank assets are distorted by a worse economy, which indicates that non-performing loans increase; on the other hand, there are many flows from bank liabilities in a recession, when depositors expect a large number of bank failures.

5.2.2.4 Existing Evidence on the Study of Banking Crises/Failures

One of the prevalent studies on banking crises is Demirguc-Kunt and Detragiache (1998), who investigated the causes of banking crises[59] by applying a large dataset of developing and developed countries from 1980 to 1994 to a multivariate logit model. The results indicate that macroeconomic variables and law enforcement significantly affect bank performance. Lower GDP growth increases the risk level of the banking sector without a lag effect. A higher interest rate tends to increase the probability of banking crises, while little evidence is found for the effect of exchange rates on banking crises. In addition, the problem of moral hazard associated with deposit insurance is highlighted in countries with a lower quality of law enforcement, which increases the probability of banking crises. This suggests that an implicit protection of depositors is preferred to resolve the moral hazard problem. However, this study leaves open questions related to the effect of other factors on banking crises, such as the competition of financial markets, liquidity assets and capital ratio.

Another paper by Demirguc-Kunt and Detragiache (1999) indicates that factors, including interest rate, GDP, M2, credit per capita, terms of trade change and depreciation, should be considered to monitor banking crises using two different tools, in terms of 36 banking crises from 65 countries. The application of an early warning system (EWS) using estimated crisis probability and constructing a rating system, respectively, have proved to be a useful preliminary screen to monitor banking crises. However, this estimation still concentrates on macroeconomic indicators.

Demirguc-Kunt and Huizinga (2009) suggest that the application of a universal banking

[59] This is defined according to at least four conditions being held: 1. Non-performing loan ratio is more than 10%; 2. rescue cost is at least 2% of GDP; 3. Nationalisation of banks is considerable; and 4. Government provides emergent measures, such as general deposit guarantees in response to the crisis (Demirguc-Kunt and Detragiache, 1998).

model enhances a higher level of risk-taking (measured by the z-score[60]). Using data on 1334 banks from 101 countries leading up to the financial crisis in 2007-2008, they find that an excessive reliance on non-interest income and non-deposit funding can be proved to be dangerous: bank diversification is associated with a complex and risky product line, which leads to the agency problem in the bank; on the funding side, non-deposit funding adjusts the interest rate quickly according to the risk level of bank projects, which generates higher funding costs and, further, causes bankruptcy. The authors also examine the effect of banking strategy on the financial crisis in 2007-08, and suggest that a bank with more traditional activities is safer than one with higher diversification with a risky and complex product line. Similarly, Saunders and Walter (1994, pp204-205) show potential gains from a universal banking model using a simulation approach based on US data on financial institutions, insurance companies and security borders and dealers from 1984 to 1988. However, large involvement in non-traditional banking activities increases the level of risk-taking and operational costs, which leads to a decline in bank profitability.

Reinhart and Rogoff (2008) studied the US banking crisis in 2007-08 compared with 18 post-war banking crises. They suggest that the equity and housing prices in the US significantly affected the recent banking crisis, and GDP and current account were badly distorted in the run-up to the banking crisis. In addition, the characteristics of this financial crisis are similar to previous banking crises in the developed countries. By using a dataset of 14 developed countries from OECD on banking crises, Barrell *et al*. (2010) find that the un-weighted capital adequacy ratio and the liquidity ratio have an impact on the probability of banking crises through a logit model. The higher level of capital ratio and liquidity ratio

[60] This is defined as the sum of return-on-asset and equity ratio divided by the standard deviation of return-on-asset for an individual bank.

reduces the likelihood of crises. The results from out-of-sample 2007 are proved to be reliable for averting banking crises, which implies the importance of capital ratio and liquidity ratio in determining financial crises.

Regarding individual bank failure, some earlier studies contribute to this stream. According to the GH model (1999), the author also provides an empirical study using data on 4,000 banks from the US and Colombia to investigate the factors involved in banking system distress. The results indicate that both bank-specific variables, such as liquidity asset, bank risk-taking and bank profitability, and macroeconomic variables, such as GDP, affect the probability of bank failure. Using an international dataset from 1988 to 2002, Heffernan (2003) also suggests that bank- and macro-level variables tend to be the determinants of bank failure, using a logit model. The results show that a higher level of bank income, liquidity assets and bank size reduce the probability of bank failure, and higher inflation rates, lower real interest rates and lower exchange rates lead to bank failure.

According to the empirical review, most studies concentrate on the indicators of banking crises; these factors based on the emerging financial markets and advanced financial markets are quite different. It is rare to find a single factor leading to a bank crisis; instead, a combination of various factors can explain bankruptcy. However, little evidence can be found to identify the reasons for individual bank failure, particularly in the context of the recent financial crisis, taking into consideration the huge rescue funding for insolvent banks, for example, the US Treasury injected $250 billion into nine major banks in 2008 (Gorton and Metrick, 2012) paid for by taxpayers. Understanding individual bank failure is the first step to protecting the whole banking system and further saving social costs of rescuing problematic

banks. Therefore, in this chapter, based on the modified GH model by considering changes in bank behaviour and the size effect, we employ both bank-specific variables and macroeconomic indicators to identify empirically the causes of bank failure in the developed countries of Europe and North America. Furthermore, we construct a study in order to distinguish the factors of bank failure that occurred both in the lead-up to the recent episode of financial crisis and the unfolding of this episode. Table 5-1 provides a summary of empirical studies on the determinants of banking crises/failures.

Table 5-1 A Summary Review on the Studies of Banking Crisis/ Failure						
Authors	Year	Study period	Sample country	Methodology	Explanatory variables	Main findings
Barker and Holdsworth	1994	1986-1991	The US banks	Logit model	(1) Loans of real estate (2) Proxies of banking sector situation	(1) A large amount of real estate loans increases the probability of bank failure. (2) A worse banking system increases the probability of bank failure.
Demirguc-Kunt and Detragiache	1998	1980-1994	45-65 countries depending on each regression	Logit model	(1) GDP growth rate (2) Changes in the terms of trade (3) Exchange rate (4) Real interest rate (5) Inflation rate (6) Surplus/GDP (7) M2/foreign exchange reserves (8) Liquidity ratio (9) Real domestic credit growth (10) GDP per capital	(1) Lower GDP, higher interest rate and inflation rate tend to increase the probability of banking crises. (2) Explicit deposit insurance increases the probability of banking crises.
Demirguc-Kunt and Detragiache	1999	1980-1995	65 countries	Logit model	(1) GDP growth (2) Terms of trade change (3) Exchange rate (4) Real interest rate (5) Inflation rate (6) Fiscal surplus/GDP (7) M2/Reserve (8) Credit growth (9) GDP per capital	(1) A higher level of GDP growth and GDP per capital reduces the probability of banking crises. (2) A higher level of real interest rate and inflation increases the probability of banking crises. (3) A higher level of M2 and credit growth increases the probability of banking crises.
Gonzalez-Hermosillo	1999	1980-1995	The US Mexico and Colombia	Logit model; Cox proportional hazard model	(1) Non-performing loan ratio (2) Equity ratio (3) Proxies of market risk (4) Proxies of liquidity risk (5) Proxies of moral hazard (6) Proxies of macro-economy	(1) Higher non-performing loans and lower level equity ratio increase the probability of bank failure and decrease the survival time of banks. (2) Liquidity risk and market risk play an important role in determining banking

					(7) Bank specific variables: income ratio; profit margins; loan ratio; salary ratio; bank size; expenses to fixed assets	crises and the survival time of banks. (3) A weak bank system accelerates the bank failure.
Hutchinson and Mc-Dill	1999	1975-1997	132 countries	Probit model	(1) Proxy of central bank independence (2) Deposit insurance (3) Proxy of liberalization (4) GDP growth rate (5) Exchange rate depreciation (6) Real credit growth (7) Real interest rate (8) Inflation (9) Change in the stock markets	(1) A lower level of the output price and the equity price leads to an increase in the probability of banking crises. (2) A higher level of central bank independence, explicit deposit insurance, financial liberalization and moral hazard accounts for banking crises.
Logan	2000	1991-1994	The UK	Logit model	(1) Loan growth (2) Net interest income (3) Proxy of liquidity risk (4) Bank profits (5) Leverage ratio	(1) A large leverage reduces the probability of bank failure. (2) A higher level of credit risk and liquidity risk increases the probability of bank failure.
Heffernan	2003	1988-1992	6 developed countries: Australia, Finland, France, Norway, Sweden and the US	Logit model	(1) Net income/TA (2) Liquidity ratio (3) Loan loss provision (4) Bank size (5) Asset growth rate (6) Inflation (7) Real exchange rate (8) Real interest rate	(1) An increase in net income reduces the probability of bank failure. (2) A higher level of liquidity ratio and loan quality reduces the probability of bank failure. (3) A higher level of inflation rate and real exchange rate increases the probability of bank failure.
Davis and Karim	2008	1979-2003	105 countries	Logit model; Signal extraction approach	(1) Real GDP growth (2) Change in terms of trade (3) Nominal depreciation (4) Real interest rate	(1) The Logit model is better than the Signal extraction approach in terms of a global dataset. (2) Macro-level variable: a higher level of

					(5) Inflation (6) Fiscal surplus/GDP (7) M2/foreign exchange reserves (8) Credit to private sector/GDP (9) Liquidity ratio (10)Real domestic credit growth (11)Real GDP per capital (12)Deposit insurance	GDP growth rate and GDP per capital decreases the probability of banking crises; while a lower level of real interest rate and inflation rate decreases the probability of banking crises. (3) Financial variables: a higher level of M2, private credit ratio and credit growth increases the probability of banking crises. (4) Fiscal policy: a higher level of fiscal balance reduces the probability of banking crises. (5) Institution: a higher level of deposit insurance reduces the probability of banking crises.
Barrell, Davis, Karim and Liadze	2010	1980-2007	OECD countries	Logit model	(1) Real GDP growth (2) Real interest rate (3) Inflation (4) Fiscal surplus/GDP (5) M2/foreign exchange reserves (6) Real domestic credit growth (7) Liquidity ratio (8) Un-weighted capital adequacy ratio (9) Real property price growth	(1) Capital requirement, liquidity assets and housing price index play an important role in determining the probability of banking crises, which tends to exclude the traditional indicators of macro-economy, such as GDP, inflation, exchange rates. (2) A higher level of liquidity ratio and capital ratio mitigates the probability of banking crises. (3) Reducing the house price growth leads to a lower probability of banking crises.

5.3 Introduction of the Limited Dependent Model and Variables

5.3.1 The Logit Model

The indicator models (signal extraction) do not perform better compared with a multivariate logit (probit) model. The signal extraction approach[61], first, is based on the effect of an individual factor on the probability of banking crises; second, the way to generate a common threshold across countries averages away the heterogeneity of sample countries; and third, a common threshold in some cases is correct, while in some circumstances it is not appropriate: for example, a change in a country's market structure may lead to a different distribution of an indicator, which generates another optimal threshold. Thus, this approach is preferable for estimating banking crises for individual countries. However, a multivariate logit (probit) model can investigate the effect of a combination of various factors on the probability of bank failure, and it can capture the heterogeneity of sample banks[62] when estimating a large number of bank failures across countries (Davis and Karim, 2008). Therefore, specifically, a multivariate logit model is used in this chapter for identifying the reasons for bank failure.[63]

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[61] This is a non-parametric methodology. The idea behind it is that if a single variable exceeds the threshold of this indicator, it is thought to be as an abnormal behaviour; this can be used to predict banking crises. Basically, it concentrates on a particular behaviour related to crises (Davis and Karim, 2008). The best threshold of a single indicator for each country depends on minimising the noise-to-signal ratio defined as type 1 error/(1-type 2 error); and then all the best thresholds are averaged as a general threshold across countries.

[62] As suggested by Demirguc-Kunt and Detragiache (1998), using a fixed logit model leads to a correlation between the country-specific dummy and the financial crisis dummy, which requires the estimation to eliminate the countries without experiencing banking crises. This generates a biased sample, since a large number of countries are excluded. My study also has this problem that a correlation between the bank-specific dummy and the bank failure dummy (in other words, dependent variable y_{it} does not change over time, including no information for estimating coefficients, see Wooldridge, 2010, p622) excludes a large number of individual living banks, leading to a biased sample when using a fixed logit model. However, the transformation of a logit model with random effects can capture unobserved individual heterogeneity ("random logit model allows us to compute partial effects for different individuals as described by the heterogeneity…, all we can really do is estimate the partial effects for different values of heterogeneity" see Wooldridge, 2010, pp614-619). Moreover, Demirguc-Kunt and Detragiache (1998,1999) also used a logit model with random effects to estimate banking crises. Therefore, we believe that the estimation with a full sample by using a logit model with random effects is reasonable.

[63] Davis and Karim (2008) and Riportella et al. (2010) point out that the probit model is equally valid in the context of estimating bank failure. Thus, we also estimated the causes of bank failure using a multivariate probit model. The results do not suggest any significant differences compared with the logit model. Thus, we only present the estimation based on a multivariate logit model.

The probability of bank failure dummy variables depends on estimated variables using a logistic cumulative distribution. Thus,

$$Prob(y_{it} = j) = \mathrm{F}(\beta X_{it}) = \frac{exp^{\beta' X_{it}}}{1 + exp^{\beta' X_{it}}} \quad (5\text{-}4)$$

where,

y_{it} is a bank failure dummy variable for bank *i* at time *t*.

j=0 or 1: y=1donotes bank failure and y=0 denotes living bank.

$\mathrm{F}(\beta X_{it})$ is the logistic cumulative distribution function.

X_{it} is a vector of explanatory variables.

β is a vector of coefficients and can be estimated by a maximum likelihood function.

The possible values of *y* (0 or 1) contribute to the joint likelihood function, thus, a log-likelihood function is shown:

$$LnL = \sum_{i=1}^{N} \sum_{t=1}^{T} [y_{it} LnF(\beta' X_{it}) + (1 - y_{it}) LnF(1 - \beta' X_{it})] \quad (5\text{-}5)$$

where,

LnL is a natural log likelihood function.

i=1….*N*, is the number of individual banks.

T=1999,…, 2008, is the year.

The right-hand-side depends on the logistic cumulative distribution function, thus, the coefficient β does not suggest a change of the probability of bank failure in response to a

unit change of independent variables. To find the marginal effect of independent variables on the probability of bank failure P(y=1|*X*), the mathematic calculus is shown:

$$\frac{\partial p(X)}{\partial x_j} = \frac{dF(\beta' X)}{dx_j} \cdot \beta_j \tag{5-6}$$

In the logit case, the cumulative distribution is an increasing function, thus, $\frac{dF(\beta' X)}{dx_j}$ is positive, which suggests that the sign of the marginal effect depends on the β_j. In this study, we report the coefficients of the marginal effect of the explanatory variables.

5.3.2 Overall Model Performance

According to Amemiya (1981), three criteria are indicated to evaluate overall model performance: Model Chi-square (Model χ^2), Akaike's Information Criterion (AIC) and the prediction accuracy. First, Model Chi-square is to test whether the joint coefficients of independent variables are equal to zero. The null hypothesis is that the coefficients are jointly equal to zero. If the Chi-square statistic is more than the critical value, given the degree of freedom, we can reject the null hypothesis. Second, the AIC is defined as the sum of the log-likelihood of the model and the number of estimated variables. The smaller the value of AIC, the better the overall model performance is presented. Third, calculating the predicted accuracy depends on the estimated probability of bank failure. We present the total percentage of observations that are correctly classified. The Percentage of Correct Predictions (PCP) is generated by comparing the predicted probability with the observed probability of bank failure. Thus, PCP reflects the goodness-of-fit of models.

5.3.3 Data Selection

The criteria are employed to generate the sample. First, we restrict the sample period from 1999 to 2008 to investigate the reasons for bank failure, since we are interested in the factors involved in bankruptcy after 2000, particularly for the recent banking crisis, owing to the large amount of complicated financial products used post-2000[64], which has a significant impact on bank performance. Second, living banks must be alive during the entire period (1999-2009), and if any banks were bankrupt at any time during the period (2000-2009) they are indicated as failed banks[65]. The sample used in this study is unbalanced panel data, which might miss some observations for individual banks. Table 5-2 reports the observed number of banks in each country, including both living banks and failed banks.

Table 5-2 The Numbers of Banks in Sample Countries

Country	No. of living bank	No. of failure bank	Total
France	70	27	97
Germany	65	27	92
Canada	27	17	44
Switzerland	49	16	65
The UK	39	40	79
The US	64	36	100
Total	314	163	477

[64] The sample countries follow the previous chapter: France, Germany and the UK are representatives for the EU; Switzerland as a European country is a representative for outside the EU; Canada and the US are representatives for North America. The Gramm-Leach Bliley Act was proposed in 1999, which removed barriers in the US financial markets between commercial banks and investment banks, so the amount of non-traditional activities significantly increased from1999 onwards. Thus we can consider these sample countries as a whole, especially regarding non-traditional activities. For the statistics of the size of the derivative market, please see http://www.bis.org/statistics/derstats.htm.

[65] The failed bank in this chapter is defined as bankruptcy, in liquidation or in dissolved situation based on the definition provided by Bankscope. The list of failed banks in each country is shown in Appendix 6.

5.3.4 The Choice of Explanatory Variables

The GH model (1999) shows the role of important factors, including bank profitability, capital adequacy and bank risk-taking in determining bank failure, and bank risk-taking is conditioned by macro-variables. Therefore, it attempts to integrate bank- and macro-level variables to examine bank distress. However, the GH model does not consider the effect of bank diversification, which is a significant change in bank behaviour that has an impact on bank performance, so it is not applicable in the context of the recent financial crisis, which was mainly affected by the employment of non-traditional activities. In addition, considering the policy of TBTF, the effect of bank size under TBTF has been reviewed in the previous chapter in the context of the interbank markets, suggesting that large banks are associated with a higher risk level. Thus, in this chapter, we modify the GH model considering product diversification and bank size effect to investigate the factors affecting the probability of bank failure. Therefore, the explanatory variables in this study can be arranged into four categories: Bank risk-taking (RISK), Macro-variables and Regulation (MV&RG), Bank specific variables (BS) and Bank diversification (BD).

(1) Variables of Fundamental Risk-taking (RISK)

Recalling Eqs.5-1 and 5-2 suggested by the GH model (1999), *RISK* consists of liquidity risk, default risk and interest rate risk. *InterR* is a proxy of real interest rate risk, which is defined as the difference between the interbank rate (one-year)[66] and the change of the Consumer Price Index (CPI) according to the GH model. They are chosen from Datastream and international financial statistics (IMF). Generally, a higher level interbank rate increases bank sensitivity to macroeconomic shocks. In addition, Nys (2003), Panetta, Schivardi and Shum

[66] Treasury bill rate (one-year) is used for the US due to data availability.

(2004) and Banal-Estonol and Ottaviani (2007) point out that the interbank market rate can be a measure of the marginal costs of interbank lending. An increase in interbank rates leads to a higher level of lending costs and reflects market attitude towards problematic banks. Thus, the sign of interest rate risk is expected to be positive.

CredR (z-score) is a proxy of default risk, which is defined as the sum of return-on-assets and equity ratio divided by the standard deviation of return-on-assets for an individual bank (calculated over the sample period for each bank)[67]. Data are chosen from Bankscope. According to the studies of Erel (2005), Focarelli and Panetta (2002) and Sapienza (2002), the loan loss provision ratio is a backward-looking measure of credit risk, which can be used to support other measurements, such as the non-performing loan ratio. However, using a historical loss rate as a measure is not appropriate in downturns, where the loss rate might be overestimated and hence cannot precisely reflect the economic situation (Beatty and Liao, 2009). Moreover, using the loan loss provision ratio as a measure of credit risk may lead to a biased result, particularly in a recession, where banks are more sensitive to the losses. Therefore, z-score has been broadly applied in recent banking studies (see Lepetit et al., 2008a; Demirguc-Kunt and Huizinga, 2009; Michalak and Uhde, 2009; Strobel, 2011). Since this study concentrates on bank failure in the context of the recent financial crisis, we use a z-score as a proxy of credit risk. Z-score is expected to be negatively related to the probability of bank failure. This is because an increase in bank profits and equity ratio or a decline in the standard deviation of bank profits indicates a lower default risk, which would reduce the probability of bank failure.

[67] The z-score used here is a cross-sectional measurement; However, Lepetit and Strobel (2013) provide time-varying z-score measures, which could be subjected to my future research.

LiqiR is a proxy of liquidity risk, which is defined as the ratio of liquidity assets to total bank assets. Data are chosen from Bankscope. The liquidity assets include trading securities, at fair value through income, cash and due from bank, and loan and advances to banks. The greater the liquidity assets, the greater probability that banks can survive in the event of unexpected withdrawals. Nevertheless, inefficient bank management of liquidity assets may increase operational costs, which has a negative impact on bank performance. Thus, the liquidity ratio is expected to be either negative or positive.

(2) Bank diversification (BD)

In this chapter, we modify the GH model, considering the effect of changes in bank behaviour on the probability of bank failure. NII is a measure of the shift towards non-traditional bank activities, which is defined as non-interest income to total operating income, according to Calmes and Theoret (2010), Stiroh (2006), Stiroh and Rumble (2006) and Stiroh (2004). They suggest that a higher level of bank diversification (product diversification) increases the level of risk-taking and reduces the profitability of banks. My empirical results in Chapter 2 suggested that the diversification of bank activities has a negative impact on bank profitability. Data are chosen from Bankscope

(3) Bank specific variables (BS)

Based on the GH model (1999), ROA (return on assets) is a measure of bank profitability, which is defined as profit-before-tax to total assets. Data are chosen from Bankscope. The GH model suggests that the probability of bank failure depends on bank profitability and the sign of ROA is expected to be negative, which is straightforward.

As this study aims to investigate individual bank failure, the difference between large and small banks should be included, considering TBTF. The bank size effect has been found for large banks in the context of interbank lending, as shown in Chapter 3. Size is defined as a log-transformation of bank assets. Data are chosen from Bankscope. To some extent, the policy of TBTF appeared in all countries, according to Heffernan (2005, p395), particularly in the US, for example, the case of Continental Illinois in 1984[68]. Stiroh and Rumble (2006) suggest that regulators and governments have been concerned about the cost of bankruptcy. If a bank fails, the loss value of assets, the cost of searching for new management and the cost for shareholders and customers are considerable, especially for large sized banks. The purpose of bail-out for big banks is to protect the banking system against higher volatility resulting from individual large bank failure. Therefore, we expect that the bank size has a significant impact on the probability of bank failure.

(4) Macro-variables and Regulation (MVRE)

Based on the implications of the GH model, the probability of bank failure depends on macro-economic shocks. Since this study mainly focuses on bank failure up to the recent financial crisis related to the housing market. Thus, besides the GDP growth rate, we take the housing market index into consideration. REPI is the real estate price index, which is a measure of the house prices for all countries other than the US, where the purchase price index of existing home with mortgage is used because of data availability. Data are chosen from Datastream. As suggested by Barrell et al. (2010) and Beltratti and Morana (2009), a rapid increase in housing prices indicates a higher potential risk of mortgages related to the house market bubble. Once the bubble bursts, this may lead to numerous defaults on bank

[68] Continental Illinois was renamed Continental Bank, and was nationalization in 1984. The US government gradually released control of Continental Bank, until 1991, when the process was completed.

mortgages, which in turn significantly increases the probability of bank failure. Particularly in the recent financial crisis of 2007-08, housing prices played an important role in determining the scenario of bank failure. Therefore, this offers an intuition that we can split the entire period and investigate the specific effect of the housing market on bank failure in terms of the lead-up to the crisis and the crisis period.

GDP is the GDP growth rate, which is defined as GDP in the year *t* minus GDP in *t-1* divided by the value of GDP in *t-1*. Data are chosen from international financial statistics (IMF). As a traditional indicator of the economy, GDP is used in many studies (see Demirguc-Kunt and Detragiache, 1998, 1999; Hutchinson and Mc-Dill, 1999; Davis and Karim, 2008; Liadze et al., 2010). The better the macroeconomic performance, the lower the probability of bank failure. Thus, the sign of the GDP growth rate is expected to be negative.

Regarding capital regulation, the GH model explicitly suggests that capital adequacy has a significant impact on bank failure. *CapiR* is a measure of the capitalisation of banks, which is defined as total regulatory capital to total bank assets. A higher level of capital ratio can increase banks' incentive to engage in prudent activities, which in turn reduces the probability of bank failure. However, some economists (see Hovkimian and Kane, 2000; Barth et al, 2001, 2004) imply the inefficiency of capital regulation in controlling for bank risk-taking. A higher level of regulatory capital may increase the amount of non-performing loans and this, in turn, increases the probability of bank failure, since in order to offset regulatory costs, banks are inclined to operate activities associated with a higher level of risk-taking to obtain higher profits. Thus, the sign is to be either positive or negative.

(5) Country-specific effect

As this study includes countries from the EU, outside the EU but in Europe, and North America, considering the fundamental differences in banking systems and market structures, we try to capture the country-specific effect using interaction variables and country dummies.

C_Dummy is country dummy variables to capture the country specific effect. The value is equal to 1 for a certain country, 0 otherwise, taking Canada as a base .

C_Vari is interaction variables in terms of individual countries. Considering the country-specific effect of bank-level explanatory variables on the probability of bank failure, interaction variables are used in this study. This is defined as the original values of the explanatory variables multiplied by 1 for a certain country, 0 otherwise. Table 5-3 shows a summary description of all variables

Table 5-4 reports the statistics of the bank specific explanatory variables for both living banks and failed banks in terms of each country. Generally, taking the mean values into consideration, failed banks are associated with a higher level of credit risk and a lower level of ROA and capital ratio compared with living banks, which is consistent with the GH model. We also note that failed banks are accompanied by a higher level of liquid assets, suggesting a higher level of operational costs due to inefficient liquidity management. However, we cannot identify any significant difference between living banks and failed banks in terms of bank size. Table 5-5 shows the matrices of correlation among bank-level variables.

Table 5-3 A Description of Variables

Variables	Symbols	Descriptions	Sources
Dependent variable	y	It is equal to 1 that indicates a bank failure; and zero indicates a living bank during sample time.	----
RISK	InterR	It is defined as the difference between the interbank rate (1-year) and the change of CPI.	Datastream; International financial statistics; Author's calculation
	CredR	It is called z-score, and is defined as the sum of return-on-asset and equity ratio divided by the standard deviation of return-on-asset of each individual bank.	Bankscope; Author's calculation
	LiqiR	It is defined as the ratio of liquidity assets to total bank assets.	Bankscope; Author's calculation
BD	NII	It is defined as the ratio of non-interest income to total operating income.	Bankscope; Author's calculation
BS	ROA	It is defined as the ratio of profit-before-tax to total assets.	Bankscope; Author's calculation
	Size	It is defined as a log-transformation of bank assets.	Bankscope; Author's calculation
MV&RE	REPI	Real estate price index for sample countries; the purchase price index of existing home with mortgage for the US	Datastream
	GDP	It is defined as GDP in this year minus GDP in the last year divided by the value of GDP in the last year.	International financial statistics; Author's calculation
	CapiR	It is defined as the total regulatory capital to total bank assets.	Bankscope
Country specific effect	C_Dummy	Country-specific dummy variables.	Author's calculation
	C_Vari	Country-specific interaction variables in terms of bank specific explanatory variables.	Author's calculation

Table 5-4 Statistics of Bank Specific Variables in Sample Countries

	Failed banks			Living banks		
France	Mean	Max	Min	Mean	Max	Min
CredR	0.196	1.629	-0.141	0.270	2.235	-0.065
LiqiR	34.60	100.0	0.000	22.10	100.0	0.000
NII	55.50	90.00	-133.3	66.50	125.0	-160.8
ROA	1.022	10.00	-8.930	2.346	47.00	-13.10
SIZE	3.382	5.450	1.204	3.386	5.824	0.903
CapiR	11.15	95.68	0.080	14.72	98.90	-4.130
	Failed banks			Living banks		
Germany	Mean	Max	Min	Mean	Max	Min
CredR	0.106	1.657	-0.076	0.138	1.518	0.019
LiqiR	25.60	95.50	2.20	17.50	98.60	0.000
NII	4.400	133.3	-32.5	31.10	239.2	-106.2
ROA	-1.15	7.550	-12.73	0.462	8.570	-30.77
SIZE	2.989	4.480	1.146	2.700	4.372	1.113
CapiR	8.300	94.23	0.160	10.16	97.84	0.230
	Failed banks			Living banks		
Canada	Mean	Max	Min	Mean	Max	Min
CredR	0.228	1.161	0.026	0.242	1.785	-0.096
LiqiR	16.10	61.70	0.000	12.80	51.50	0.000
NII	19.40	61.30	0.000	31.00	180.0	-57.00
ROA	1.179	36.62	-0.41	1.568	25.73	-6.46
SIZE	2.385	4.936	1.342	3.176	5.385	1.146
CapiR	12.32	36.04	1.000	13.78	94.86	0.28
	Failed banks			Living banks		
Switzerland	Mean	Max	Min	Mean	Max	Min
CredR	0.169	1.545	-0.165	0.363	1.80	-1.321
LiqiR	44.70	99.20	4.200	39.60	99.10	0.000
NII	-78.20	111.2	-338.8	56.80	175.0	-130.0
ROA	0.119	12.28	-24.00	2.299	75.98	-56.39
SIZE	3.720	5.691	1.875	2.568	5.804	0.698
CapiR	10.45	93.26	-4.630	20.66	94.00	-27.12
	Failed banks			Living banks		
The UK	Mean	Max	Min	Mean	Max	Min
CredR	0.213	1.932	0.007	0.664	2.068	-0.168
LiqiR	17.30	94.60	0.000	29.80	100.0	-181.1
NII	32.50	125.0	-350.0	86.80	246.7	-180.0
ROA	0.725	36.78	-41.42	2.020	48.00	-67.94
SIZE	2.644	5.661	2.389	2.776	5.680	0.301
CapiR	12.64	98.49	0.360	39.97	100.0	-7.160
	Failed banks			Living banks		
The US	Mean	Max	Min	Mean	Max	Min
CredR	0.255	3.452	-28.32	0.388	5.204	-0.306
LiqiR	19.60	100.0	0.000	9.200	100.0	0.000
NII	42.20	133.3	-55.50	20.10	101.4	-366.6
ROA	-3.421	118.0	-180.0	8.966	320.0	-54.48
SIZE	2.936	5.539	0.000	2.264	4.499	0.301
CapiR	19.43	100.0	4.440	15.47	100.0	-1.500

Notes: CredR: Credit risk; LiqiR: Liquidity risk; NII: the ratio of non-interest income to total operating income; ROA: Return on assets; SIZE: a log-transformation of bank assets; CapiR: Total regulatory capital ratio.

Table 5-5 The Matrices of Correlation among Bank-level Variables

	CredR	LiqiR	SIZE	NII	ROA	CapiR
CredR	1.000					
LiqiR	0.105	1.000				
SIZE	-0.123	0.005	1.000			
NII	0.019	0.020	0.026	1.000		
ROA	0.596	0.051	-0.034	0.010	1.000	
CapiR	0.381	0.198	-0.318	0.036	0.096	1.000

Note: CredR: Credit risk; LiqiR: Liquidity risk; NII: the ratio of non-interest income to total operating income; ROA: Return on assets; SIZE: a log-transformation of bank assets; CapiR: total regulatory capital ratio.

5.4 Results and Analyses of Empirical Work

5.4.1 Basic Model

Since this study is mainly interested in the causes of bank failure in the context of the recent banking crisis in 2007-08, we tend to estimate empirically based on two sub-periods: 1999-2005 and 2006 -2008[69]; prior to the main estimation, we use the Chow test (1960) to identify whether there is a break within the sample period. The statistic of the Chow test is F(10, 3489)=29.22, which is more than the critical value (2.34) at the 1% significant level. Thus, we can reject the null hypothesis, in other words, there is a break within the whole period (1999-2005 and 2006-2008), so that we can investigate the causes of bank failure in terms of these two sub-periods.

Table 5-6 shows the empirical results and overall model performance using a logit model in two sub-periods. Regarding RISK, z-score is a composite indicator of credit risk and has a significant and negative effect on the probability of bank failure in all estimations. This result is consistent with the implication of the GH model (1999), which suggests that a higher credit risk of banks usually stems from the default of borrowers, who are not able to repay owing to macroeconomic shocks; or are not willing (but are able) to repay lending, which may result

[69] The failed time of banks for the first sub-period is from 2000 to 2006, and for the second sub-period it is from 2007 to 2009.

from inefficient credit risk management. Thus, higher credit risk leads to a higher probability of bank failure.

The liquidity ratio as a measure of the liquidity assets is positive and significant in the estimation in the earlier sub-period. This result is contrary to the implications of Gonzalez-Hermosillo's (1999) theoretical work and the empirical findings of Demirguc-Kunt and Detragiache (1998), Logan (2000) and Heffernan (2003), suggesting that depositors have less confidence in bank performance, which triggers a bank run, particularly for banks with lower liquidity assets. This may further lead to a bank panic, as depositors doubt the repayment ability of other banks, considering asymmetric information. One possible explanation for my result is that inefficient liquidity management generates a higher level of operational costs, which is a reason for bankruptcy (Heffernan, 2005).

Regarding bank specific variables (BS), return-on-assets (ROA) as a measure of bank profitability is significant and negative in all estimations, which is consistent with the implications of Gonzalez-Hermosillo's (1999) theoretical work and the empirical findings of Logan (2000) and Heffernan (2003). The explanation is straightforward: a higher level of ROA increases bank profitability against potential risk-taking, which in turn reduces the probability of bank failure. In addition, the size effect is positive and significant in the estimations with the sub-period of 2006-2008, which is contrary to the findings of Gonzalez-Hermosillo (1999), Heffernan (2003) and Carling et al. (2004). The result fails to indicate "too big to fail"; in contrast, large banks are associated with a higher probability of bank failure. This can be interpreted by the view that because of the advantages (information availability, advanced technology and operating experiences) of large banks, they have more

opportunities to be involved in risky activities than small banks, particularly non-traditional banking activities, which may increase the volatility of bank profits (Deyoung and Roland, 2001; Stiroh, 2004; Stiroh and Rumble, 2006). In the second sub-period (during the crisis), governments allowed problematic large banks to fail, i.e., Bear Stearns and Lehman, since the funding requirement for rescuing large banks is huge, which is consistent with the argument of "too big to save" (Demirguc-Kunt and Huizinga, 2011).

As concerns macro-variables and capital regulation (MV&RG), the significant coefficients of housing prices are found in all estimations. However, they vary in terms of different sub-periods. A positive result is indicated in the sub-period 1999-2005, which is consistent with Barrell et al. (2010) and Beltratti and Morana (2009). A rapid increase in housing prices indicates a housing market bubble and leads to potential higher risk-taking of banks with the large amounts of mortgage loans, which in turn increases the probability of bank failure. On the other hand, the negative result in the estimations of the later sub-period (2006-2008) suggests that, once the bubble bursts, banks cannot receive the re-payment of mortgage loans, particularly derivative markets, where large numbers of financial products with mortgage loans, i.e., CDS and CDO, default. As a result, the probability of bank failure increases, which is consistent with the scenario of the developed financial markets in 2007-08. These two different results in terms of housing prices can be used to support the argument of Reinhart and Rogoff (2008) that housing prices increase prior to a banking crisis, while the bubble bursts during the crisis. However, we do not find any significant coefficients of GDP growth rate in all estimations, which indicates that the economic situation, in terms of international trade, national income, consumption and spending, may have no impact on the probability of bank failure; instead, housing prices play an important role in determining the probability of bank failure occurring after 2000, particularly during the recent financial crisis.

The coefficients of capital ratio are positive and significant in all estimations, which is contrary to the implication of the GH model, but does follow the implications of the theoretical work of Kim and Santomero (1988), Koehn and Santomero (1980), Rochet (1992) and Demsetz and Strahan (1997). They suggest that, given a serious capital requirement, banks are inclined to operate risky activities associated with a higher level of profits in order to offset the regulatory costs, which increases the probability of bank failure. This result is also consistent with the empirical findings of Hovkimian and Kane (2000) and Barth et al. (2001, 2004). We do not find any significant parameters of interest rate risk and non-interest income share in all estimations, thus, we may try to control for the country specific effect in terms of these variables, using the interaction variables.

As concerns overall model performance, Model Chi-square values are more than the critical value at the 1% significant level for all estimations, so we can reject the null hypothesis, which indicates that the estimated variables are not jointly equal to zero. In other words, employing these explanatory variables is reasonable. The overall model performance is better in the case of the earlier sub-period, owing to a lower AIC. To address the prediction accuracy of the logit model, the percentages of correct predications (PCP) are reported. All values of PCP imply that over 90% of samples are correctly classified. Therefore, these models perform well in general.

Table 5-6 Results of Basic Models in Two Sub-periods

Dependent variable: Banking crisis dummy	1999-2005	2006-2008
InterR	0.234	-0.148
	[1.20]	[-1.23]
Cred	-7.928***	-11.41***
	[-9.77]	[-14.69]
LiqiR	4.141***	1.24
	[3.82]	[1.43]
NII	-0.041	-0.022
	[-0.49]	[-0.32]
ROA	-0.075***	-2.018***
	[-9.08]	[-14.68]
CapiR	0.055**	1.74***
	[2.70]	[11.55]
Size	-0.468	0.348**
	[-1.57]	[2.14]
REPI	0.013**	-0.005**
	[2.36]	[-2.67]
GDP	0.14	-0.056
	[0.84]	[-0.52]
Constant	-0.808	-2.33**
	[-0.50]	[-2.62]
Diagnostics		
Total observations	2321	1188
Model Chi-square (9)	76.43***	34.88***
AIC	-470.65	-249
PCP	92.96%	91.34%

Notes: InterR indicates interest rate risk; CredR indicates credit risk; LiqiR indicates liquidity risk; NII is non-interest income share; ROA is asset on return; CapiR is regulatory capital ratio; Size is a log-transformation of bank assets; REPI is housing price index; GDP is GDP growth rate. AIC is Akaike's Information Criterion; PCP is the Percentage of Correct Predictions; *, **, *** indicates that coefficients are significant at the 10%, 5% and 1% significant level, respectively; t-statistics are in [].

5.4.2 Extended Model with Country Dummies and Interaction Variables

Because of fundamental differences in banking structures and financial regulation across countries, we take country dummy variables into consideration, and we also use interaction

variables of non-interest income ratio, controlling for the country specific effect[70]. Table 5-7 shows the results of the estimations. The results of the Wald test Chi-square (6) show that we can reject the null hypothesis that all coefficients of interaction variables of non-interest income share are jointly equal to 0; thus, we use these variables in the estimations.

Based on the country dummy variables, a higher probability of bank failure is indicated in the US, especially in the later sub-period 2006-08; Overall, the magnitude of the coefficients for country dummies is higher during 2006-08 compared with the earlier sub-period, which indicates that the likelihood of bank failure is higher in the later sub-period; this result is consistent with the scenario of the recent financial crisis, which is the largest, including numerous major bank failures in developed countries, since World War II (Reinhart and Rogoff , 2008).

Regarding the interaction variables of non-interest income, the significant coefficients go in the opposite directions. Specifically, a negative result is found in the estimations of the UK, Switzerland (in the later sub-period) and Canada (in the earlier sub-period), while a positive coefficient is found in the estimations of the US. The negative result is consistent with the findings of Chiorzazzo et al. (2008), Baele et al. (2007) and Davis and Tuori (2000), who suggest that the shift towards non-traditional businesses may enhance bank performance, as an increase in non-traditional banking activities provides a function of risk-sharing and augments the risk-adjusted return. Moreover, a higher level of non-interest income can offset

[70] In this extended model, we should use interaction variables for insignificant coefficients of independent variables in the basic model to control for the country specific effect. Specifically, we used the interaction variables for interest rate risk, bank size and non-interest income share in the extended model with the earlier sub-period; and we used interaction variables for interest rate risk, liquidity risk and non-interest income share in the extended model with the later sub-period. However, the statistics of the Wald test in terms of these interaction variables are smaller (Chi-square (18) is 12.89 in the extended model with the earlier sub-period; and Chi-square (18) is equal to 18.56 in the extended model with the later sub-period) than the critical value at the 1% significant level, thus, we accepted the null hypothesis is that the coefficients of these interaction variables are jointly equal to 0. The results of the Wald test suggest that we should use the interaction variables of non-interest income ratio in the extended models.

losses from traditional banking activities; however, the positive result implies that a large involvement in non-traditional activities increases the probability of bank failure in the US, which is consistent with the findings of Calmes and Theoret (2010), Stiroh (2006), Stiroh and Rumble (2006) and Stiroh (2004). Considering the US banks, they point out that a large number of small banks dominates the US financial market, so bank diversification associated with a risky product line has a negative impact on bank performance owing to less managerial experience of operating non-traditional activities (an increase in operational costs, i.e., switching costs and information costs), which in turn increases the probability of bank failure. Generally, the differences in the structure of financial markets, regulation and supervision may contribute to these various results.

As concerns overall model performance, model Chi-square values are large enough to reject the null hypothesis at the 1% significant level for all estimations, which suggests that the estimated variables are not jointly equal to zero. All of the values of AIC are lower than that in the basic models, which imply that including dummy variables and interaction variables can improve model performance. The percentages of correct prediction are slightly higher than in the basic models.

Basically, the empirical results are following the implications of the modified GH model, especially in terms of the significant effect of non-interest income ratio after controlling for the country specific effect. The results also suggest that the importance of bank profitability, liquidity and capital adequacy in determining the probability of bank failure. The negative effect of bank risk-taking, bank size and capital ratio may result from asymmetric information and moral hazard, which do not only exist in the banking sector but also in the rest of the

economy, such as shareholders, depositors and borrowers (Heffernan, 2003). In addition, the results in terms of the two sub-periods provide evidence on the importance of the housing price index, suggesting that housing prices increase prior to the banking crisis, while they fall during the crisis leading to numerous defaults on bank mortgage loans in derivative markets, which is consistent with the argument of Reinhart and Rogoff (2008). The role of GDP as a traditional macroeconomic indicator has been replaced by the housing price index in determining bank failure, at least during the recent financial crisis.

Table 5-7 Results of Extended Models in Two Sub-periods

Dependent variable: Banking crisis dummy	1999-2005	2006-2008
InterR	0.133	0.217
	[1.01]	[0.97]
Cred	-0.01***	-10.98***
	[-4.08]	[-14.78]
LiqiR	5.559***	3.12**
	[4.15]	[2.85]
NII	----	----
ROA	-0.07	-1.94***
	[-0.37]	[-14.76]
CapiR	-0.011	1.64***
	[-1.19]	[11.10]
Size	1.147***	0.55**
	[5.51]	[2.45]
REPI	-0.01	-0.023***
	[-1.63]	[-5.08]
GDP	0.04	-0.164
	[0.31]	[-1.05]
Constant	-5.46***	-2.78**
	[-4.9]	[-1.99]
C_US	6.10***	19.30***
	[4.35]	[3.18]
C_UK	5.05***	6.67***
	[3.70]	[3.18]
C_GER	2.70**	-1.34
	[2.17]	[-0.74]
C_FRA	2.34**	4.39**
	[2.00]	[2.07]
C_SWI	3.43**	6.12**
	[2.48]	[2.59]
USNii	4.33***	5.26***
	[3.29]	[3.50]
UKNii	-0.56*	-3.33***
	[-1.67]	[-3.41]
GERNii	-0.07	-2.78
	[-0.34]	[-0.78]
FRANii	0.042	0.098
	[0.27]	[0.20]
SWINii	0.141	-1.30*
	[0.29]	[-1.65]
CANNii	-4.51*	-1.33
	[-1.81]	[-0.65]
Diagnostics		
Total observations	2384	1210
Wald test Chi(6)	56.78***	30.45***
Model Chi-square (19)	93.89***	112***
AIC	-464.57	-163
PCP	93.62%	92.33%

Notes: InterR indicates interest rate risk; CredR indicates credit risk; LiqiR indicates liquidity risk;NII is non-interest income share; ROA is asset on return; CapiR is regulatory capital ratio; Size is a log-transformation of bank assets; REPI is housing price index; GDP is GDP growth

rate. AIC is Akaike's Information Criterion; PCP is the Percentage of Correct Predictions; C_Dummy denotes country dummy variables; C_Nii denotes country specific interaction variables in terms of Non-interest income share; *, **, *** indicates that coefficients are significant at the 10%, 5% and 1% significant level, respectively; t-statistics are in [].

5.5 Conclusions

Previous empirical studies were restricted to the investigation of banking crises using country-level data. Few have provided evidence for the causes of individual bankruptcy in the context of the recent financial crisis. Therefore, this chapter investigated the factors including RISK (three fundamental risk-taking), bank specific variables (bank profitability and bank size), product diversification, and macro-variables and regulation, based on the modified GH model considering changes in bank behaviour and the size effect. Basically, the results show that these factors play an important role in determining the likelihood of bank failure since 2000. Regarding RISK, we notice that a higher probability of bank failure is induced by a higher level of liquidity assets; this is contrary to the implications of previous works, but suggests higher operational costs of managing liquidity owing to inefficient bank management.

Regarding bank specific variables, the effect of "too big to fail" cannot be identified, which reflects potential huge costs saving for governments, taking the recent financial crisis into consideration. Although central banks try to make TBTF ambiguous, it is easy for banks to analyse which banks will be protected; this in turn generates moral hazard (Heffernan, 2003). Thus, central banks may need to allow large banks to fail in order to save social costs to taxpayers.

Regarding the macroeconomic indicators, the GDP growth rate has an insignificant effect on

the probability of bank failure; instead, the housing price index presents a significant effect on bank failure. The opposite coefficients in terms of two sub-periods imply the different roles of housing prices in determining the probability of bank failure. A rapid increase in housing prices in the run-up to the financial crisis reflects a house market bubble, which augments the risk level of banks associated with mortgage loans; when the bubble bursts in the second sub-period, it leads to the default of subprime and mortgages. Therefore, these results show a complete picture of the effect of changes in housing prices on the probability of bank failure, which is consistent with the argument of Reinhart and Rogoff (2008). Regarding bank regulation, the results of the capital ratio indicate that some banks may be harmed by capital regulation, since they prefer holding risky assets to offset regulatory costs. Hence, financial policy regarding capital requirement in different sample countries should consider ways in which to protect fragile banks and at the same time avoid a consequence form moral hazard.

As regards the country specific effect, a higher probability of bank failure is presented in the US, particularly in the later sub-period 2006-08, which is consistent with the scenario of the recent financial crisis that initially stemmed from the collapse of mortgage loans in the US financial market. After controlling for the country specific effect, the opposite significant coefficients of interaction variables in terms of non-interest income are found in determining the probability of bank failure. Specifically, the employment of non-traditional activities increases the probability of bank failure in the US, this may follow the implication of Stiroh (2006), Stiroh and Rumble (2006) and Stiroh (2004) suggesting non-traditional activities associated with higher risk-taking; while it reduces the possibility of bank failure in the UK (both two sub-periods), Switzerland (the later sub-period) and Canada (the earlier sub-period).

CHAPTER 6

CONCLUSION

This thesis has investigated bank behaviour up to the 2007-08 global financial crisis in the developed countries of Europe and North America, using four studies with empirical estimations. The first three studies concentrate on off-balance-sheet activities and loans, interbank lending and interest margins, and the last identifies the causes of bank failure. In this chapter, we provide a summary of the empirical results, along with contributions and limitations of this research, and discuss the future research.

6.1 Answers to Study Questions and Contributions

Revisiting the study questions proposed in the Introduction, we can summarise the answers using the empirical results found in the previous four chapters and show the contributions of this set of studies.

- What is the effect of off-balance-sheet activities on bank performance and why, and what makes up an optimal bank portfolio including traditional activities and off-balance-sheet items?

In Chapter 2, we investigate the effect of off-balance-sheet items and traditional activities, i.e.,

loans, on bank profitability, taking the recent financial crisis into consideration. We firstly use standard portfolio theory (Stiroh and Rumble, 2006; Stiroh, 2006) as a basis to investigate bank diversified gains: the negative results of the non-interest income ratio suggest that the diversified gain is reduced if there is a positive correlation between interest income and non-interest income owing to the cross-selling of financial products. Then we consider a framework for the shift of OBSs in a bank portfolio, given a fixed capacity of bank activities in the three sub-periods (1996-2000; 2001-2006 and 2007). The implication of this framework is that, considering credit rationing for loans[71], banks prefer holding more OBSs in order to make higher profits post-2000. However, the negative result of OBSs on bank profitability is not consistent with this implication and potentially suggests that idiosyncratic risk can be diversified, but the overall portfolio risk is higher and cannot be diversified. In addition, we present a framework of changes in the capacity of a bank portfolio including both OBSs and traditional activities, i.e., loans, in the three sub-periods. In regard to this framework, four cases are discussed, taking the situation in 1996-2000 as a base. In the sub-periods 2001-2006 and 2007, regarding the capacity of bank activities: first, both OBSs and loans shift in the same proportion, suggesting an increase in the loans' proportion in a bank portfolio, leading to a higher expected bank return in equilibrium; second, loans shift more than OBSs, suggesting an increase in loans in a portfolio, leading to a higher expected return in equilibrium[72]; third, OBSs shift more than loans, suggesting a higher proportion of OBSs and lower proportion of loans in a bank portfolio, leading to a lower expected return in equilibrium; and fourth, OBSs shift up but loans shift down, suggesting a higher proportion of OBSs and low proportion of loans in a bank portfolio, leading to a lower expected return; however, the expected return in

[71] In the theoretical work, we present the effect of credit rationing on the composition of a bank portfolio, while the higher competition and regulation in the traditional market also drive changes in the composition of bank portfolios, especially regarding OBSs.

[72] As shown in Figure 2-4, in Cases 1 and 2, since both the bank capacity and the equilibriums (A' A" or E'E") move to the right, we cannot show whether the proportion of OBSs increases in a bank portfolio. However, we still can find a higher expected return with a large proportion of loans, whatever the proportion of OBSs.

equilibrium (A") in 2007 in Case 4 is lower than that of Case 3 as shown in Figures 2-5 and 2-6. The negative results of OBSs and positive results of loans in the sub-periods 2001-2006 and 2007 follow the scenarios described in the third and fourth cases, suggesting that banks are involved in more OBSs but fewer loans, leading to a lower bank return owing to the higher risk and leverage resulting from inappropriate bank regulation and bank risk management. This result indicates an overcapacity problem regarding OBSs in a bank portfolio. The huge losses from the recent financial crisis have already called the positive effect of OBSs into question, requiring a policy response to distinguish between OBSs and loans. Thus, finally in this chapter we provide a theoretical work on the effect of a risk-based capital requirement on bank portfolios. The implication of this model is that banks are willing to operate more traditional activities with less risk-taking when facing large regulatory costs, given a risk-based capital requirement. The empirical result of the interaction variables between OBSs and the dummy of capital requirement is consistent with this implication, suggesting that a risk-based capital requirement generates a substitution in a bank portfolio away from risky assets, i.e. OBSs, to more traditional activities.

Bank diversification (product diversification) has been a recent financial innovation, which contributes to the improvement of bank performance; however, this chapter states that an increase in OBSs has a negative effect on bank profitability, suggesting that an optimal bank portfolio should go for fewer OBSs: this seems reasonable, particularly taking the recent financial crisis into consideration. One possible interpretation is that cross-selling of financial products creates a positive link between interest income and non-interest income, according to the efficient set theory, which limits the benefits from bank diversification as demonstrated by the negative coefficients of non-interest income ratio in the three sub-periods. The other is the

overcapacity problem, especially regarding OBSs, as demonstrated by the negative coefficients of OBSs in the sub-periods, since banks have more incentive to enlarge the range of activities, which might be driven by the TBTF policy and stronger competition in traditional credit markets; however, traditional risk management is unable to hedge the risk of OBSs associated with complex characteristics, and inappropriate regulation also leads to higher risk-taking and leverage of non-traditional activities. In addition, given a risk-based capital requirement, banks should reduce the amount of OBSs holdings associated with higher risk-taking, because of considerable regulatory costs. This highlights the importance of capital regulation in solving the overcapacity problem regarding OBSs.

- Does an increase in interbank lending lead to higher risk-taking by banks, particularly considering the bank size effect?

The moral hazard problem has been enhanced during the recent financial crisis, especially in the context of the interbank market, where a large problematic bank potentially participates in a bail-out provided by the central bank (CB) in order to avoid a contagion risk resulting in an unstable financial system. This leads to the large bank possible being willing to become involved in more risky activities, which is the consequence of TBTF. In Chapter 3, we modify Dinger and Hagen's (2005) model by considering the effect of TBTF suggested by Freixas et al. (2000), and we attempt to test three hypotheses: first, large banks protected by governments are associated with higher risk-taking under TBTF; second, an increase in interbank assets leads to a higher risk level of large banks as they have less incentive to monitor borrower activities; and third, that higher equities or deposits protect banks against the liquidity problem, so they are associated with a lower risk level, especially for small banks lacking protection from CB. Therefore, a threshold model in terms of bank size (Hansen, 2000,

and Caner and Hansen, 2004) is applied to endogenously divide banks into large and small groups in order to examine these hypotheses. The positive results of interbank assets in the large bank group imply that under the policy of "Too big to fail", large banks have more incentive to engage in risky assets and less incentive to monitor borrowers, as they participate in potential bail-outs, which leads to higher risk-taking of interbank assets. The positive result of bank size on bank risk-taking found in the large bank group can also represent evidence for a consequence of moral hazard resulting from TBTF. The negative result of equity ratio in the small bank group suggests that small banks with large equities are likely to be safe, since shareholders have to monitor banks' activities because of a lack of protection from CB, while this result is insignificant for large banks; overall, these results can support three assumptions. Considering the time trend, the coefficients of year dummy variables suggest that the level of risk-taking reduced over time for small banks, while the risk level of large banks increased, in particular after 2005. This might be a result of the fact that because of advantages in technology, management and information, large banks are inclined to engage in non-traditional activities associated with higher risk-taking, compared with small banks specialising in traditional activities. In addition, the magnitude of the negative effect of interbank lending on bank risk-taking was higher during the crisis period (2006-2008) when numerous banks with a shortage of liquidity had to refinance through the interbank markets.

The liquidity problem of banks can be eased through the interbank markets; however, this chapter highlights a moral hazard problem in the context of interbank lending. Under the "too big to fail" policy, the size effect is significant in determining the risk-taking of interbank assets. An increase in interbank assets leads to higher risk-taking in the large bank group, which suggests that they have less incentive to monitor borrowers considering the protection

from CB. In addition, a hazardous incentive is found in shareholders, who have less incentive to monitor large banks protected by CB. This chapter shows that a lack of comprehensive regulation from both CB and shareholders, especially regarding large banks, might be a possible explanation for the recent financial crisis.

- What is the effect of changes in bank behaviour on interest margins?

Chapter 2 has shown that banks expand the scope of activities by increasing non-traditional activities partly because of higher competition in the traditional activities, which has an impact on bank income structure. Thus, in Chapter 4, we examine the effect of changes in bank behaviour on the determinants of interest margins, based on the multi-product bank model of Valverde and Fernández (VF) (2007), controlling for institutional imperfections, such as implicit payment, opportunity cost and the cost of holding capital. In addition to a significant effect of interest rate risk on interest margins, the VF model suggests that product diversification has a negative effect on interest margins, since it is associated with higher non-interest income that can be used to offset losses from traditional activities, i.e., loans, arising from higher regulatory costs and competition in the loan market. This chapter provides a country-by-country study, considering fundamental differences in banking systems and market structures, and this heterogeneous assumption is also identified by a robustness test. The significant coefficient of product diversification is found in a market-based financial system, i.e., those in the US and the UK, where banks with large non-traditional activities depend less on the traditional intermediary function; this leads to a lower interest income. However, this is insignificant in a bank-based financial system, such as France and Germany, where banks are reliant on traditional activities. This negative effect of product diversification also follows the conjecture of Lepetit *et al*. (2008b), who argue that in order to absorb new

customers, banks lower the price of traditional activities so that they can sell non-traditional products to the customers (cross-selling), the interest margin is therefore reduced. In addition, the positive coefficient of concentration ratio 5 indicates that banks in a less competitive market have more power to charge higher interest rates, which increases interest margins. The positive result of interest rate risk is found in most of the sample countries, where interest rate risk plays an important role in determining net interest margins following the theoretical model of Ho and Saunders (1981) and Valverde and Fernandez (2007). Therefore, this chapter may show an implication for policy-makers, who should pay more attention to the effect of diversification in a market-based financial system, such as those of the US and the UK, where banks heavily rely on bank diversification associated with a risky product line.

- Why do some banks fail while others do not?

The previous three chapters investigated the effects of bank behaviour, such as OBSs and interbank lending, bank size, bank risk-taking and capital regulation. In Chapter 5, we use these variables plus macroeconomic shocks to evaluate the causes of bank failure based on a modified Gonzalez-Hermosillo (GH) (1999) model considering product diversification and the size effect, as Chapter 2 has shown that bank diversification is associated with a risky product line, which has a negative impact on bank performance, considering the recent financial crisis; and Chapter 3 has implied the role of the size effect in determining bank risk-taking, considering the consequence of TBTF in the context of the interbank market. In Chapter 5, we find the significant effects of risk-taking, capital adequacy and the profitability of banks on the probability of bank failure, which is consistent with the implications of Gonzalez-Hermosillo (1999). We also find significant coefficients of product diversification after controlling for the country specific effect. It is worth noting that the positive coefficient

is only found in the US, suggesting that bank failure is induced partly by a higher level of product diversification, since a large number of small banks with less experience of operating non-traditional activities dominates the US bank market, which increases operational costs and bank risk-taking; and the cross-selling of financial products also reduces diversified benefits (see Calmes and Theoret, 2010; Stiroh, 2006; Stiroh and Rumble, 2006; Stiroh, 2004). The positive result of bank size during the crisis period (2006-2008) fails to indicate TBTF; in contrast, large problematic banks, i.e., Bear Stearns and Lehman, were allowed to become bankrupt, considering the huge cost of funding for rescuing banks, which is consistent with the argument of "too big to save" (Demirguc-Kunt and Huizinga, 2011). Regarding macro-variables, in the context of the recent financial crisis, we find that the proxy of housing prices replaced the traditional macroeconomic indicator, i.e., GDP, in determining bank failure, and this generates different effects on bank failure in terms of two sub-periods. An increase in housing prices in the early period (1999-2005) leads to a higher level of the probability of bank failure, owing to a potential housing market bubble, while a negative result in the later period (2006-2008) suggests that the probability of bank failure increases, since the financial products that depend on house prices are associated with abnormally higher risk-taking when the bubble bursts. This presents a complete picture of the effect of housing prices on the bank industry in the run-up to a financial crisis and the crisis period, suggesting that the effect of the traditional macroeconomic indicator, GDP, has been replaced by the proxy of housing prices in the context of the recent financial crisis, as demonstrated by the insignificant coefficient of GDP. Basically, this chapter presents the causes of bank failure, considering changes in bank behaviour and housing prices, which is the first step towards understanding the mechanism of the global financial crisis in 2007-08.

6.2 Remarks and Policy Implications

The results of the four empirical studies generate some concerns surrounding bank regulation that need to be discussed along with policy recommendations. The first concern is bank regulation imposed on non-traditional activities. As shown by the results in Chapter 2, the application of bank diversification does not increase bank profits, while it does lead to the volatilities of bank return. The overcapacity problem of bank portfolios regarding OBSs challenges bank regulation and supervision. According to Furfine (2001), Mullings (2003) and Francis and Osborne (2009), we derive a theoretical model to compare the composition of bank portfolios in two cases, one considering a risk-weighted capital regulation and the other not. According to the implications of this model, the marginal benefits of OBSs and loans are reduced as risk-based capital regulation is augmented; moreover, the reduction in the marginal benefits of OBSs is more than that of loans, which shows that the introduction of risk-based capital requirement leads to a shift away from risky assets, i.e., OBSs, to safe assets in a bank portfolio when facing considerable regulatory costs. Therefore, we believe that policy-makers should implement prudent regulation and supervision, i.e., pay attention to leverage ratio and liquidity ratio, and impose an appropriate capital requirement on OBSs with a risky product line in order to maintain a stable financial market.

The second concern is bank regulation imposed on large banks. The large banks are associated with a higher level of risk-taking, as shown by the results in Chapters 3 and 5, potentially suggesting that regulation does not work for big banks. The possible explanation stems from the impact of “Too big to fail”. According to the argument of Heffernan (2005, p395), all countries adopt TBTF to some extent; for example, France has a 100% safety net to protect large banks. The aim of TBTF is to provide final protection for large banks in order to

maintain a stable financial system, since large bank failures harm the whole financial system. However, the justification for TBTF is called into question. First, based on O'Hara and Shaw (1990), Kane (2000), Penas and Unal (2004) and Jagtiani and Keeton (2008), the TBTF policy gives rise to a problem of moral hazard. Large banks are reluctant to monitor bank behaviour but concentrate on maximising bank profits without considering the level of risk-taking, which may generate higher social costs from taxpayers. Second, all banks are willing to make efforts, i.e., enlarge non-traditional activities, to become large in order to benefit from TBTF. However, inefficient risk management is not able to hedge the risk-taking of non-traditional activities with complicated characteristics; this causes higher level bank risk, further leading to bank failure, since the funding requirement for rescuing large banks is considerable ("too-big-to-save" suggested by Demirguc-Kunt and Huizinga, 2011). Therefore, policy-makers on one side should provide bail-outs for large banks in order to build a stable financial market; on the other side, the moral hazard problem associated with TBTF should also be taken into account.

The third concern is around regional and global bank regulation. Chapter 4 has identified the difference in bank operations and financial systems among sample countries. The response to shocks may vary across countries, suggesting that a global standard regulation might not be efficient; instead, a single regime based on one region, i.e., ECB[73], might be more applicable for banking regulation and supervision. In addition, the results for equity ratio and loan deposit ratio in Chapter 3 suggest that comprehensive bank regulation, including government, shareholders and depositors, is essential to protect banks from bankruptcy.

[73] Since the sample in this study is based on countries from the EU, outside the EU but in Europe and North America, the result of the Wald test indicates differences among these countries, which is reasonable; but this does not challenge the regional integration for banking regulation, i.e., ECB, which needs an investigation exclusively using more ECB members as a sample.

6.3 Future Research

This thesis has shown an optimal bank strategy regarding traditional activities and non-traditional activities; the effect of interbank assets on bank risk-taking considering TBTF; the effect of the change in bank behaviour on interest margins; and identified the reasons for bank failure. It has also contributed evidence for the argument that there is a close relationship between financial markets and economic growth. However, some further related studies need to be conducted in the future.

First, this thesis aims to investigate bank behaviour up to the 2007-08 global financial crisis and to compare bank activities in the run-up to the crisis with those in the crisis period. To make the results more comparable, we would extend the study period until 2012 and form a panel dataset with a longer period. The empirical results would be used to suggest differences in bank behaviour in three sub-periods: pre-crisis, crisis and post-crisis, which would give a complete view regarding the effect of bank behaviour on bank performance, and allow the further proposal of more reliable policy implications.

Second, the sample countries in this thesis are major developed countries in Europe and North America, but do not include any developing countries, i.e., BRICs[74]. Although the recent financial crisis has been significant in Europe and North America, it has also had an impact on the financial sectors of developing countries, through different approaches from those in developed countries. For example, the financial crisis has led to a global economic recession, particularly for the economic growth of developing countries which mainly rely on international trade with developed countries. To some extent, slow economic growth

[74] The BRICs include Brazil, Russia, India and China.

generates changes in the banking sector. i.e., increasing default risk. Therefore, it is worth examining bank behaviour in developing countries in the context of the financial crisis.

Third, we believe that other factors also contribute to the study of bank behaviour. The effect of bank behaviour on bank performance depends on financial systems and financial regulation (Heffernan, 2005, p285). It is necessary for policy-makers to balance the probable gains and losses, prior to implementing financial policy. Considering policy implications, to test the effect of bank behaviour, the differences in the law systems and political structures in the sample countries should be estimated. Therefore, any aims beyond the purposes of this thesis could be subjected to future research.

APPENDIX

Appendices for Chapter 2

Appendix 1: The efficient set theorem

According to standard portfolio theory,

$$E(R_p) = E(r_o)q + E(r_t)(1-q) \quad (1)$$

$$\sigma_p^2 = \sigma_o^2 q^2 + \sigma_t^2 (1-q)^2 + \sigma_o \sigma_t \cdot \rho_{obstra} 2 \cdot q \cdot (1-q) \quad (2)$$

The definitions of variables are displayed in the main body of the thesis.

Assume that $r_o > r_t$ and $\sigma_o > \sigma_t$,

Where,

r_o, r_t are the expected returns of OBSs and traditional activities, respectively.
σ_o, σ_t are the risk of OBSs and traditional activities, respectively.

Case 1: the correlation between OBS and traditional banking activities is equal to 1, the risk of the portfolio is calculated from Eq.2.

$$\sigma_p = q\sigma_o + (1-q)\sigma_t \quad (3)$$

$$q = \frac{\sigma_p - \sigma_t}{\sigma_o - \sigma_t} \tag{4}$$

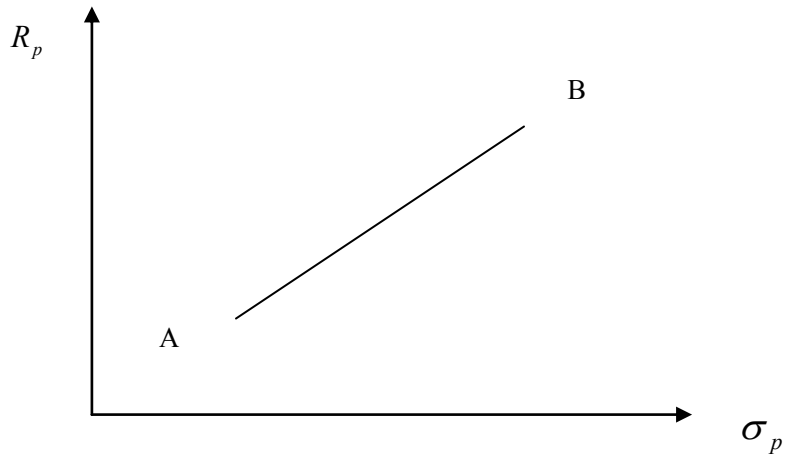
Substituting Eq.4 into Eq.1,

$$R_p = (\frac{\sigma_p - \sigma_t}{\sigma_o - \sigma_t}) \cdot r_o + (1 - \frac{\sigma_p - \sigma_t}{\sigma_o - \sigma_t}) \cdot r_t \tag{5}$$

$$R_p = [\frac{\sigma_t (r_t - r_o)}{\sigma_o - \sigma_t} + r_t] + (\frac{r_o - r_t}{\sigma_o - \sigma_t})\sigma_p \tag{6}$$

Recalling the assumptions, thus, the relationship between them is linear, and the slope is positive. Figure 1 shows a linear line between A (OBS) and B (Traditional behaviour) to display the relationship between the risk and the expected return of the portfolio when the correlation is equal to 1

Figure 1: Relationship between return and standard deviation when the correlation is equal to1



Case 2: the correlation between OBS and traditional banking activities is equal to -1, the risk

of the portfolio is calculated from Eq.2. There are two results to be considered.

$$\sigma_{p1} = q\sigma_o - (1-q)\sigma_t \tag{7}$$

$$\sigma_{p2} = (1-q)\sigma_t - q\sigma_o \tag{8}$$

According to Eq.7,

$$q = \frac{\sigma_{p1} + \sigma_t}{\sigma_o + \sigma_t} \tag{9}$$

Substituting Eq.9 into Eq.1,

$$R_{p1} = [\frac{\sigma_t (r_o - r_t)}{\sigma_0 + \sigma_t} + r_t] + (\frac{r_o - r_t}{\sigma_o + \sigma_t}) \cdot \sigma_{p1} \tag{10}$$

Recalling the assumption $r_o > r_t$, the relationship between the return and risk of the portfolio is linear and the slope is positive.

According to Eq.8,

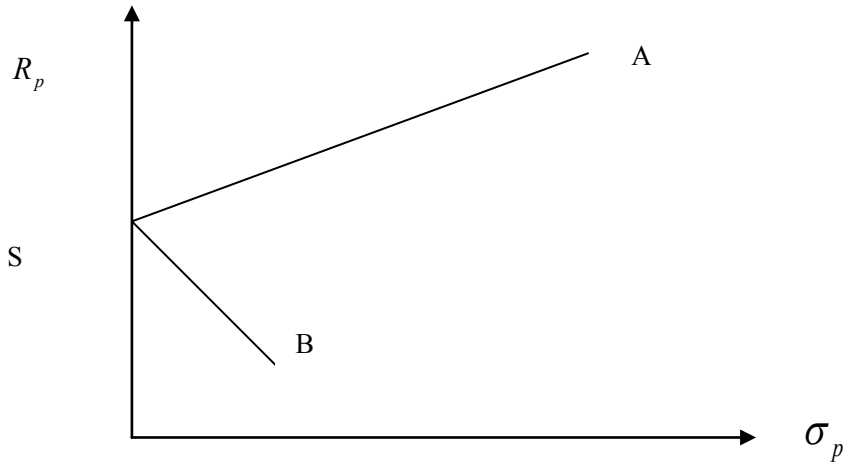
$$q = \frac{\sigma_t - \sigma_{p2}}{\sigma_o + \sigma_t} \tag{11}$$

Substituting Eq.11 into Eq.1,

$$R_{p2} = [\frac{\sigma_t (r_o - r_t)}{\sigma_0 + \sigma_t} + r_t] + (\frac{r_t - r_o}{\sigma_o + \sigma_t}) \cdot \sigma_{p1} \tag{12}$$

Recalling the assumption $r_o > r_t$, the relationship between the return and risk of the portfolio is linear and the slope is negative. The risk of the portfolio is equal to zero, requiring that the proportion of OBSs is the ratio of the risk of traditional activities to the sum of the risk of OBSs and risk of traditional activities, at the point S, where $q = \frac{\sigma_{tra}}{\sigma_{tra} + \sigma_{obs}}$, as shown in Figure 2.

Figure 2: Relationship between return and standard deviation when the correlation is equal to -1



Case 3: the correlation between OBS and traditional banking activities is equal to zero; the risk of the portfolio is calculated from Eq.2 and shown as below:

$$\sigma_p = (q^2\sigma_0^2 + (1-q)^2\sigma_t^2)^{0.5} \quad (13)$$

$$\sigma_p^2 = (q^2\sigma_0^2 + (1-q)^2\sigma_t^2)$$

$$q^2(\sigma_o^2+\sigma_t^2)-2\sigma_t^2 q+(\sigma_t^2-\sigma_p^2)=0 \tag{14}$$

The results in terms of Eq.14 are shown as below:

$$q_1=\frac{\sigma_t^2+\sqrt{\sigma_p^2(\sigma_o^2+\sigma_t^2)-\sigma_o^2\sigma_t^2}}{\sigma_o^2+\sigma_t^2} \tag{15}$$

$$q_2=\frac{\sigma_t^2-\sqrt{\sigma_p^2(\sigma_o^2+\sigma_t^2)-\sigma_o^2\sigma_t^2}}{\sigma_o^2+\sigma_t^2} \tag{16}$$

Substituting Eq.15 into Eq.1,

For the simplicity, set $X=\sqrt{\sigma_p^2(\sigma_o^2+\sigma_t^2)-\sigma_o^2\sigma_t^2}$,

$$R_{p1}=[\frac{\sigma_t^2(r_o-r_t)}{\sigma_o^2+\sigma_t^2}+r_t]+(\frac{r_o-r_t}{\sigma_o+\sigma_t})\cdot X \tag{17}$$

Substituting Eq.16 into Eq.1

$$R_{p2}=[\frac{\sigma_t^2(r_o-r_t)}{\sigma_o^2+\sigma_t^2}+r_t]+(\frac{r_t-r_o}{\sigma_o+\sigma_t})\cdot X \tag{18}$$

Since X is non-linear, the relationship between the risk and return of the portfolio is also non-linear. By taking first-order-condition (FOC) with respect to the proportion of OBS (q), we can minimise the risk of the portfolio, and the result is shown as follows:

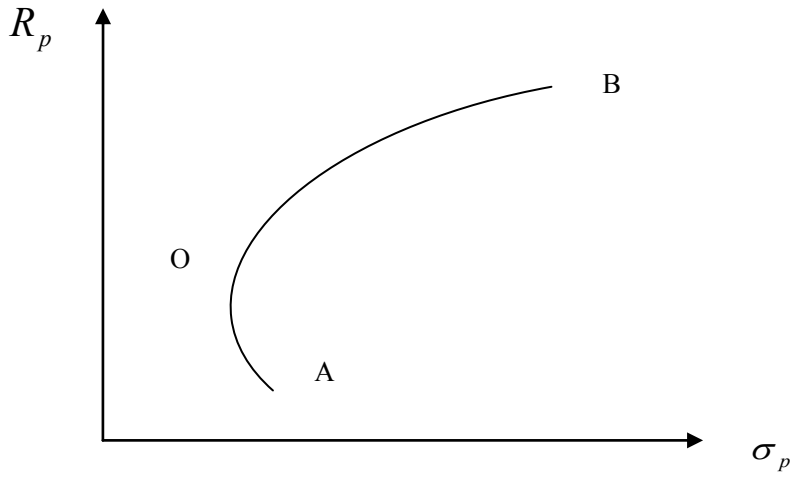
$$\sigma_p=(q^2\sigma_0^2+(1-q)^2\sigma_t^2)^{0.5}$$

$$\frac{d\sigma_p}{dq} = \frac{q\sigma_o^2 - \sigma_t^2 + q\sigma_t^2}{(q^2\sigma_o^2 + (1-q)^2\sigma_t^2)^{0.5}} = 0 \tag{19}$$

$$q^* = \frac{\sigma_t^2}{\sigma_t^2 + \sigma_o^2} \tag{20}$$

With the value of q^*, the risk of the portfolio is minimised at the point O, as shown in Figure 3. It shows a non-linear line between A (OBSs) and B (Traditional behaviour) to display the relationship between the risk and the expected return of the portfolio when the correlation is equal to 0. We can minimise risk-taking of the portfolio at the point O.

Figure 3: Relationship between return and standard deviation when the correlation is equal 0



Appendix 2: Modelling the Impact of Risk-based Capital Requirement on Bank Portfolio

In this model, there are two periods. In period 1, without considering risk-based capital regulation, we maximise the utility of the bank and the result is shown as follows:

$$U = r_t^l L_t + r_t^s S_t + r_t^o OBS_t - C_t \tag{1}$$

where,

U: the utility of the bank

L: bank loans

OBS: off-balance-sheet activities; both bank loans and OBSs are risky assets compared with government securities. Assume that the risk level of OBSs is higher than that of bank loans.

S: government securities

r_t^l: the interest rate of loans

r_t^s: the interest rate of government securities

r_t^o: the rate of return of OBSs

C: the costs, such as costs of issuing equities and adjustment costs.

The evolution of capital is shown:

$$K_t = K_{t-1} + r_t^l L_t + r_t^s S_t + r_t^o OBS_t - r_t^d D_t + Q_t \tag{2}$$

where,

K_t : capital holding at t

K_{t-1} : capital holding at t-1

r_t^d : the interest rate of deposits

D_t : deposits

Q: the equities issued by banks

Therefore, the balance sheet is identified as L+S=D+K.

All items are divided by 1- r_t^d , the result is shown:

$$K_t = \frac{1}{1-r_t^d}[K_{t-1} + r_t^l L_t + r_t^s S_t + r_t^o OBS_t - r_t^d L_t - r_t^d S_t + Q_t] \tag{3}$$

To maximise the utility of the bank,

$$\phi = \int_0^\infty \{\delta^t (r_t^l L_t + r_t^s S_t + r_t^o OBS_t - C_t) + \lambda[K_t - \frac{K_{t-1}}{1-r_t^d} - \frac{r_t^l L_t}{1-r_t^d} - \frac{r_t^s S_t}{1-r_t^d} - \frac{r_t^o OBS_t}{1-r_t^d} + \frac{r_t^d L_t}{1-r_t^d} + \frac{r_t^d S_t}{1-r_t^d} - \frac{Q_t}{1-r_t^d}]\} d_t \tag{4}$$

The results of the first order condition (F.O.C.) in terms of S, OBSs and L, respectively, are shown as follows:

$$r_t^s + \lambda(\frac{r_t^d - r_t^s}{1-r_t^d}) = 0 \tag{5}$$

$$r_t^o - \lambda(\frac{r_t^o}{1-r_t^d}) = 0 \tag{6}$$

$$r_t^l + \lambda(\frac{r_t^d - r_t^l}{1-r_t^d}) = 0 \tag{7}$$

In the period 2, risk-based capital regulation is considered. Assume that the risk of government securities is 0, so the capital holding in terms of government securities is 0.

The utility function of the bank is shown:

$$U = r_t^l L_t + r_t^s S_t + r_t^o OBS_t - (\alpha_t L_t + \beta_t OBS_t) g(k_r^R - d_t) - C_t \tag{8}$$

where,

d_t: a minima of risk-based capital requirement.

α: risk weights of loans

β: risk weights of OBSs; assume that $\beta > \alpha$.

k_r^R: risk-based capital ratio, and it is defined as $\frac{K_t}{\alpha_t L_t + \beta_t OBS_t}$.

g: a function of the adjusted costs of additional capital holding $(k_r^R - d_t)$, thus, the regulators desire $k_r^R > d_t$; g is a decreasing function and g' <0. The function g is multiplied by risk-weighted assets to capture all risky assets that are subjected to the capital requirement in the period 2.

C is the costs.

The evolution of capital follows that in the period 1.

Therefore, the integration function is shown by considering the maximisation of the utility:

$$\phi = \int_0^{\infty} \{\delta^t (r_t^l L_t + r_t^s S_t + r_t^o OBS_t - (\alpha_t L_t + \beta_t OBS_t) g(k_t^R - d_t) - C_t) + \lambda[K_t - \frac{K_{t-1}}{1-r_t^d} - \frac{r_t^l L_t}{1-r_t^d} - \frac{r_t^s S_t}{1-r_t^d} - \frac{r_t^o OBS_t}{1-r_t^d} + \frac{r_t^d L_t}{1-r_t^d} + \frac{r_t^d S_t}{1-r_t^d} - \frac{Q_t}{1-r_t^d}]\} d_t \quad (9)$$

The results of F.O.C in terms of S, OBS and L, respectively, are shown:

$$r_t^s + \lambda(\frac{r_t^d - r_t^s}{1-r_t^d}) = 0 \quad (10)$$

$$r_t^o - \beta_t[g(k_t^R - d_t) - g'(k_t^R - d_t)k_t^R] - \lambda(\frac{r_t^o}{1-r_t^d}) = 0 \quad (11)$$

$$r_t^l - \alpha_t[g(k_t^R - d_t) - g'(k_t^R - d_t)k_t^R] + \lambda(\frac{r_t^d - r_t^l}{1-r_t^d}) = 0 \quad (12)$$

As capital regulation imposed on government securities is 0, the marginal benefits of government securities are equal in terms of two cases (Eq.5=Eq.10).

Subtracting Eq. 6 from Eq.11,

$$-\beta_t[g(k_t^R - d_t) - g'(k_t^R - d_t)k_t^R] < 0 \quad (13)$$

The sign of Eq.13 depends on the g function. Since g is a decreasing function, g' <0, -g'>0, thus, Eq.13<0, which suggests that the marginal benefits of OBSs is reduced as risk-based capital regulation is considered in the period 2.

Subtracting Eq.7 from Eq.12,

$$-\alpha_t[g(k_t^R - d_t) - g'(k_t^R - d_t)k_t^R] < 0 \quad (14)$$

The sign of Eq.14 is also negative, which follows the explanation of Eq.13. This

indicates that the marginal benefit of loans is reduced in the period 2 owing to the introduction of a risk-based capital regulation.

Recalling the assumption $\beta > \alpha$, so the absolute value of Eq.13 is more than that of Eq.14, which suggests that the reduction in the marginal benefits of OBSs is more than that of loans in the presence of a risk-based capital requirement. This theoretical model implicitly shows a conjecture that the introduction of risk-based capital requirement leads to a shift from risky assets to safe assets in a bank portfolio.

Appendix 3: Proof of q* (see Eq. 2-11 in the main body of the thesis)

$$q^* = \frac{\beta - 1 + \sqrt{\beta - \beta^2}}{2\beta - 1} \tag{1}$$

$$As\ 0.5 < \beta < 1,\quad -0.5 < \beta - 1 < 0;\ |\beta - 1| < 0.5;\ 2\beta - 1 > 0\ and\ 0 < \beta - \beta^2 < 0.25$$

We derivative Eq.1 with respect to β, and the result is shown:

$$\frac{dq^*}{d\beta} = \frac{(1 + \frac{1 - 2\beta}{2\sqrt{\beta - \beta^2}})(2\beta - 1) - 2(\beta - 1 + \sqrt{\beta - \beta^2})}{(2\beta - 1)^2} \tag{2}$$

The denominator is always positive, and we suppose that the numerator is negative, therefore,

$$(1 + \frac{1 - 2\beta}{2\sqrt{\beta - \beta^2}})(2\beta - 1) - 2(\beta - 1 + \sqrt{\beta - \beta^2}) < 0$$

$$(1 - 2\beta)(2\beta - 1) < -2\sqrt{\beta - \beta^2} + 4(\beta - \beta^2)$$

$$2\sqrt{\beta - \beta^2} < (2\beta - 1)^2 + 4(\beta - \beta^2)$$

$$2\sqrt{\beta - \beta^2} < 1$$

$$\beta - \beta^2 < 1/4 \tag{3}$$

If the numerator is negative, requiring that Eq.3 should be held. As β is strictly

between 0.5 and 1, $\beta - \beta^2 < 1/4$. Therefore, q* function is a decreasing function with $0.5 < \beta < 1$.

$$\lim_{\beta \to 0.5^+} q^* = \frac{1 + \frac{1-2\beta}{2\sqrt{\beta - \beta^2}}}{2} = 1/2$$

$$\lim_{\beta \to 1^-} q^* = 2\sqrt{\beta - \beta^2} = 0$$

Thus, q* is a decreasing function and strictly between 0 and 0.5 with $0.5 < \beta < 1$.

Appendices for Chapter 3

Appendix 4: The Results of the Non-linear Regression

The estimated function is shown as below:

$$Risk_{ijt} = Lasset_{ijt} + Lasset^2{}_{ijt} + interbankassetratio_{ijt} + loandeporatio_{ijt} + equityratio_{ijt} + GDP_{jt} + Interbankrate_{jt} + c + \varepsilon$$

where,

Risk is measured by LLP, and is defined as the ratio of loan loss provision to total assets.

Lasset is bank size and is the log-transformation of bank total assets.

Laaset^2 is bank size squared.

Interbank asset ratio is defined as the ratio of interbank assets to total bank assets.

Loandep ratio is defined as bank loans to total deposits.

Equity ratio is defined as total equity to total bank assets.

GDP is the GDP growth rate.

Interbank rate is 3-month interbank rate.

C is a constant.

Results of the preliminary estimation

Dependent variable: Loan loss provision ratio	Coefficients	t-statistics
Bank size	-1.096***	-6.15
Bank size square	0.161***	6.15
Interbank lending	-2.58*	-1.79
Loandep ratio	0.115***	3.36
Equity ratio	-0.257***	-8.18
GDP growth rate	-0.081***	-8.93
Interbank rate	0.013*	1.67
constant	2.69***	8.07
No. of observations	4615	
Hausman test Chi2 (7)/p-value	82.99***	0.00
Overall R-square	0.81	

Notes:. ***, **, * indicates statistical significance at the 1%, 5% and 10% level, respectively.

Appendices for Chapter 4

Appendix 5: The Result of the Wald test

Variables	(1) NIM	(2) Wald test
nim1	0.390***	(1) cnim1 = 0
	(0.0544)	(2) ccore = 0
corecap	0.0294	(3) cimpli = 0
	(0.0253)	(4) coppor = 0
implicpay	-0.0170	(5) cdeposit = 0
	(0.0285)	(6) clend = 0
opporc	0.496**	(7) cother = 0
	(0.202)	(8) clr = 0
deposits	0.552	(9) cgdp = 0
	(0.840)	(10) fnim1 = 0
lending	-1.143	(11) fcore = 0
	(2.486)	(12) fimpli = 0
otherearning	-2.166	(13) fdeposit = 0
	(2.177)	(14) foppor = 0
lr	-0.0197	(15) flend = 0
	(0.0800)	(16) fother = 0
gdp	0.0747**	(17) flr = 0
	(0.0299)	(18) fgdp = 0
cr4	2.190**	(19) gnim1 = 0
	(1.029)	(20) gcore = 0
cnim1	0.0690	(21) gimpli = 0
	(0.0966)	(22) goppor = 0
ccore	0.0647	(23) gdeposit = 0
	(0.0637)	(24) glend = 0
cimpli	0.651***	(25) gother = 0
	(0.172)	(26) glr = 0
coppor	-0.349	(27) ggdp = 0
	(0.304)	(28) snim1 = 0
cdeposit	0.651	(29) score = 0
	(1.955)	(30) simpli = 0
clend	1.479	(31) soppor = 0
	(3.065)	(32) sdeposit = 0
cother	0.0975	(33) slend = 0
	(2.266)	(34) sother = 0
clr	0.0268	(35) slr = 0
	(0.149)	(36) sgdp = 0
cgdp	-0.0860**	(37) uknim1 = 0
	(0.0384)	(38) ukcore = 0
fnim1	0.031	(39) ukimpli = 0
	(0.106)	(40) ukoppor = 0
fcore	3.142***	(41) ukdeposit = 0
	(0.644)	(42) uklend = 0
fimpli	0.0528	(43) ukother = 0
	(0.0421)	(44) uklr = 0
foppor	-0.111	(45) ukgdp = 0
	(0.216)	(46) cc5 = 0
fdeposit	0.193	(47) fc5 = 0

	(0.909)
flend	2.116
	(2.528)
fother	0.663
	(2.205)
flr	-0.325*
	(0.168)
fgdp	0.0403
	(0.0460)
gnim1	-0.0327
	(0.0762)
gcore	0.00927
	(0.0324)
gimpli	0.0181
	(0.0306)
goppor	-0.495**
	(0.202)
gdeposit	0.402
	(0.880)
glend	1.982
	(2.658)
gother	2.320
	(2.365)
glr	-0.0618
	(0.115)
ggdp	-0.0721**
	(0.0313)
snim1	0.112
	(0.0770)
score	1.329*
	(0.680)
simpli	-0.00593
	(0.0291)
soppor	-0.327
	(0.261)
sdeposit	-0.802
	(0.950)
slend	-0.189
	(2.592)
sother	0.424
	(2.262)
slr	0.260**
	(0.118)
sgdp	-0.0311
	(0.0312)
uknim1	0.108*
	(0.0616)
ukcore	-0.00530
	(0.0266)
ukimpli	0.0284
	(0.0360)
ukoppor	-0.298
	(0.242)
ukdeposit	-1.201

(48) gc5 = 0
(49) sc5 = 0
(50) ukc5 = 0

F(50, 509) = 9.28
Prob > F = 0.0000

	(0.970)
uklend	1.741
	(2.544)
ukother	1.932
	(2.198)
uklr	-0.116
	(0.252)
ukgdp	-0.112
	(0.0706)
ukc5	-2.610**
	(1.206)
sc5	-0.122
	(1.097)
gc5	-0.357
	(1.055)
fc5	1.010
	(1.191)
cc5	-6.789
	(4.712)
Constant	0.337
	(0.657)
Observations	4,423
R-square	0.335
Hausman test	510
Chi-square	
Heteroskedasticity	1.2e+06***
Chi2 (510)	(0.00)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendices for Chapter 5

Appendix 6: The List of Failed Banks in Sample Countries

France (27 banks)	Royal Saint-Georges Banque, Intermedia Banque, Banque Nationale de Paris, Intercontinentale BNPI, Banque Alcyon, American Express Bank (France), Banque Leumi France SA, Bankers Trust France SA, Banque Bipop SA, Banco Popolare di Verona e Novara (France), KBL Richelieu Banque Privée, Banque Franco Portugaise, Banque Finaref, Banque Française de l'Orient BFO, Banque Marze, Banque Worms, Chase Manhattan Bank SA, Transbanque, Citibank SA, Finter Bank France, Omnibanque, Natixis Transport Finance, SOGENAL (Groupe Société Génerale), Union de Banques Régionales pour le CIC, Axa Crédit, Banque CPR, Financière de Banque et de l'Union Meunière
Germany (27 banks)	Rabobank Deutschland AG, Arab Banking Corporation, Daus & Co. GmbH, BANK COMPANIE NORG GmbH, Bank of Tokyo - Mitsubishi (Deutschland) AG, Bankhaus Partin GmbH & Co. Kommanditgesellschaft auf Aktien, Emporiki Bank - Germany GmbH, Dresdner Bank Lateinamerika AG, Mizuho Corporate Bank (Germany) AG, JP Morgan GmbH, Resba GmbH, Weserbank AG, MTBC Bank Deutschland GmbH, Dai-ichi Kangyo Bank (Deutschland) DKB, Service Bank Gmbh & Co. KG, Nissan Bank Gmbh, CIT Industrie Bank Gmbh, Caisse des Dépôts et Consignations GmbH, A&A Actienbank AG, Privatbank Reithinger GmbH & Co KG, Deutsche Handelsbank AG, Erste Rosenheimer Privatbank AG, Arab Bank AG, Credit Suisse First Boston AG, BkmU Bank AG, Gontard & Metallbank AG, Yapi Kredi Bank (Deutschland) AG, Falke Bank AG
Canada (17 banks)	UFJ Bank Canada, Deutsche Bank Canada, Banque Nationale de Paris (Canada) BNP, Dai-Ichi Kangyo Bank (Canada), Sanwa Bank Canada, Republic National Bank of New-York (Canada), Industrial Bank of Japan (Canada) (The), Bank of America Canada, Tokai Bank Canada, Sumitomo Bank of Canada, United Overseas Bank (Canada), Sakura Bank (Canada), Hanvit Bank Canada, Intesa Bank Canada, Crédit Lyonnais Canada, Dresdner Bank Canada, Bank One Canada
Switzerland (16 banks)	Redsafe Bank, Skandia Bank (Switzerland) Ltd, ASTON BANK SA, Tokai Bank (Schweiz) AG, Bank of Tokyo - Mitsubishi (Switzerland) Ltd., UFJ Bank (Switzerland) Ltd, Rüd, Blass & Cie AG, Sakura Bank (Schweiz) AG, Banque Diamantaire (Suisse) SA-Diamond Bank (Switzerland) Ltd, BIPIELLE Bank (Suisse) SA, Daiwa Securities Bank (Switzerland), Banque Galland & Cie SA, Spar-und Leihkasse Rebstein, Ersparnisanstalt

	Unterwasser, HSBC Bank (Suisse) S.A., Zurich Invest Bank AG
The UK (40 banks)	Fairbairn Private Bank Ltd, London International Bank Limited, Credit Agricole Lazard Financial Products Bank, Leumi Bank & Trust Company (Channel Island) Limited, Legal & General Bank Ltd, Kaupthing Singer & Friedlander (Isle of Man) Limited, Bank of Ireland (Jersey) Ltd, Finsbury Pavement Limited, Anglo-Romanian Bank Limited, Bank of Cyprus (London) Limited, Bank of Tokyo - Mitsubishi (UK) Limited, Bank of Wales Plc, Dao Heng Bank (London) Plc, BBVA Privanza (Jersey) Limited, Dunbar Bank Plc, BSI (Channel Islands) Limited, Financial & General Bank Plc, Alliance & Leicester Commercial Bank Plc, Gresham Trust Plc, Capital Bank Plc, Royal Bank of Canada (Jersey) Ltd, Saudi American Bank (UK) Ltd, Yorkshire Bank Plc, Riggs Bank Europe Limited, Merrill Lynch International Bank Limited (old), Bank Hofmann (Guernsey) Ltd, Cater Allen Bank (Isle of Man) Limited, Fleet Bank (Europe) Ltd, HBOS Treasury Services Plc, SBI European Bank Plc, Dexia Municipal Bank, HSBC Private Bank (Jersey) Limited, Bank of Nova Scotia Channel Islands Limited (The), Leopold Joseph & Sons (Guernsey) Limited, Cater Allen Bank (Jersey) Limited, Bristol & West International, Prudential-Bache International Bank Limited,Alliance & Leicester Plc, Bankgesellschaft Berlin (UK) Plc, BBL International (UK) Limited
The US (36 banks)	National Bank of Vernon, LBS Bank - New York, RBC Bank (USA), Alger National Trust Company, American Home Bank, N.A., Arkansas Bankers Bank, Athol-Clinton Co-operative Bank, Axsys National Bank, Banco Popular, Bank Iowa. Altoona. Iowa, Bank Iowa. Denison. Iowa, Bank Iowa. Red Oak. Iowa, Bank of Mountain View, Bay-Hermann-Berger Bank, Belk National Bank, Chevron Credit Bank. National Association, Chicago Community Bank, Citizens National Bank of Springfield, Citrus Bank. National Association, Community Bank Plymouth, Community Banks, Concord EFS National Bank, Downers Grove National Bank, Escrow Bank USA, Fireside Bank, First Capital Bank. Illinois, First Heritage Bank. Pennsylvania, First National Bank and Trust of Syracuse, First North American National Bank, First State Bank of Hill County, First State Bank. Italy. Texas, First Fed Trust Company. National Association, Grafton State Bank, Granite National Bank, Harris Bank (NH). National Association, Intercontinental National Bank

Source: Bankscope.

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