Empirical Essays on Banking Stability

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ABSTRACT

The banking industry is one of the most important components of modern economies, providing a variety of essential economic functions. However, a banking system is inherently fragile, and this has been widely witnessed during the great financial crisis in 2008. Another lesson learnt from the crisis is that the cost of a banking crisis can be substantial. Thus, it is important for us to understand how a banking system could be destabilised and thus consider the prudential policies that could be specifically designed to prevent a banking crisis from occurring.

This thesis uses micro-econometric methods to explore factors that could have an impact on banking stability. The first essay examines whether a liquidity shock to a banking system could be transmitted to other economies through a network of bank ownership. First, it constructs cross-border ownership networks for banks located in European countries. Then, it exploits the liquidity crisis generated by the 2010 European sovereign debt crisis as a quasi-natural experiment. The analysis shows that subsidiary banks located outside of Greece, Ireland, Italy, Portugal and Spain (GIIPS) but with ownership linkages to these countries have a lower loan growth rate during the crisis period, which suggests that the liquidity shock experienced by the GIIPS countries was indeed transmitted to those banks through ownership linkages. Larger subsidiary banks and those subsidiaries that were more profitable are found to be more resilient to the shock. Furthermore, It also shows that the

parent bank's characteristics affect the transmission of the shock, supporting the notion of an internal capital market operating within these banking groups.

The second essay focuses on the effect of sovereign shocks on banks' lending activities through their exposures to the distressed sovereigns. Furthermore, it identifies whether bank strength, specifically bank capital, can act as a transmission channel through which poorly capitalised bank tend to be more fragile in response to a sovereign shock. Using a rich dataset on banks' sovereign exposures from the European Banking Authority, it also disentangles the transmission channel by breaking down the type and accounting classification of the exposure. The results suggest that highly exposed banks tend to have lower lending over the crisis period. But it shows that it is banks' available-for-sale sovereign exposures that plays the key role in the transmission from sovereign distress to bank lending through the capital channel.

The third essay explores the relationship between banking competition and banking stability, using the staggered banking deregulation levied by individual states in the U.S. as a natural experiment. Specifically, it identifies the effect of the intensified competition induced by the deregulation on the stability of the U.S. banking sector. Analysis is conducted at state-level as well as bank-level, and the overall result shows that the competition shock improves banking stability at both state- and bank-level. Furthermore, it reveals that there is significant heterogeneity among banks in response to the intensified competition: intra-state competition shock has a greater effect on the stability of small banks while banks with a larger size or better profitability are more likely to be affected by the inter-state competition shock. It also suggests that there is a non-linear relationship between banking competition and stability, as the competition shock has a greater effect on banks operating in a less competitive environment.

Overall, the findings from this thesis may help regulatory authorities to maintain the stability of the banking sector in three ways. First, it helps regulators to design micro-prudential policies towards foreign banks to prevent them from transmitting foreign liquidity shocks which could potentially destabilise the domestic banking system. Second, it produces guidance on how the regulatory treatment on banks' sovereign exposures should be specified in the future macro-prudential policy framework, to better isolate banks from sovereign shocks. Third, it helps regulators to balance between policies on facilitating competition in the banking sector and those on maintaining stability of the financial system.

DEDICATION

This thesis is dedicated to my beloved grandfather, *Cao Rui*,

from whom I acquired the temperament and the spirit of a Chinese intellectual.

DECLARATION

I certify that the thesis I have presented for examination for the PhD degree of the University of Sheffield is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

I warrant that this authorisation does not, to the best of my belief, infringe the rights of any third party.

I declare that my thesis consists of about 66,000 words.

I certify that Chapter 3 of this thesis is developed based on a working paper co-authored with *Matthew Willison* and *Francesc Rodriguez-Tous*, where I contributed at least 33% of the work.

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Chapter 1

INTRODUCTION

1.1 Motivation and Objectives

The banking industry is one of the most important components of modern economies. The economic function of the banking system has been widely investigated in the literature. A banking system can be seen as a *coalition of borrowers* through which the problem of adverse selection between lenders and borrowers could be alleviated. As the model proposed by Brealey et al. (1977) suggests, firms can have a lower cost of capital if they borrow through a coalition of borrower (financial intermediation) and the cost of capital is negatively associated with the size of the coalition. Furthermore, as Bryant (1980) and Diamond and Dybvig (1983) suggest, banks can also act as a *coalition of depositors* to provide liquidity to individuals and firms in the economy in case they receive idiosyncratic liquidity shocks. In addition, banks can also function as *delegated monitors* to alleviate the moral hazard problem between borrowing firms and dispersed lenders/depositors (Mayer, 1988; Holmstrom and Tirole, 1997).

Though these economic functions of the banking system can facilitate the operation of a modern economy, the existence of banking sector can also be a threat on the stability of the economy. The theoretical models proposed by Bryant (1980) and Diamond and Dybvig (1983) point out a special intrinsic feature of the banking system which is that the system could end up with a bad equilibrium - a situation of bank run - where the welfare of each individual in the economy would be strictly worse-off. As the banking system is established based on the law of large numbers, an unexpected systemic liquidity shock to the economy can easily collapse the whole system, and this had been widely witnessed during the 2007-08 global financial crisis (e.g. the bank run on Northern Rock in 2007, and Bear Stearns followed by Lehman Brothers in 2008). Another lesson from the 2007-08 crisis is that the cost of a banking crisis can be substantial. It had been reflected by a steep decline in output and a significant rise in unemployment rate in almost all major developed economies in the aftermath of the crisis. Therefore, it is important for us to understand how a banking system could be destabilised and thus consider the prudential policies that could be specifically designed to prevent a banking crisis from occurring.

The three essays in this thesis identify factors that could have an impact on the stability of the banking system. The first essay is motivated by the extensive globalisation of the banking sector in the past two decades. Banks from one country to the next are increasingly connected by cross-border interbank lending relationships and ownership ties. Additionally, there has been a large increase in the presence of foreign-owned banks in a typical domestic banking system. The overall share of domestic banking assets held by foreign banks has increased from 15% in 1995 to 23% in 2005 (International Monetary Fund, 2007). As a result, the role of foreign banks and foreign-owned domestic banks in the banking system has become more important, in both developed countries and emerging markets. Yet the implications of increasing foreign banks are not well understood in literature.

On one hand, access to foreign banking capital may intensify the competition of the domestic banking sector, thereby stimulating financial innovation, and the efficiency of domestic companies (Claessens et al., 2001; Sturm and Williams, 2004). Such 'spillovers' can help establish a modern financial system in developing countries and lead to better financial regulations (Lensink and Hermes, 2004). On the other hand, a large proportion of foreign owned banks in the domestic banking system could increase a country's exposure to an international liquidity shock. If so, micro-prudential policies should be designed in order to limit the potential contagion so that the financial stability of the domestic banking system is preserved. Therefore, the first essay aims to identify the following issues:

1. Can a foreign liquidity shock be transmitted to the domestic banking system

through bank ownership linkages?

2. Is there any heterogeneity among banks in transmitting the liquidity shock?

3. Is this transmission more pronounced in developing economies?

The answers to these research questions can be helpful in terms of designing micro-prudential policies specifically towards foreign banks to prevent them from transmitting foreign liquidity shocks which could potentially destabilise the domestic banking system.

A previous version of the first essay was submitted to the special issue of the *Journal of International Financial Market, Institutions and Money* (JIFMIM) on 'Cross Country Issues on Credit, Banking, Asset Pricing, and Market Liquidity' in early 2016. After two rounds of conferences held for the special issue, and one round of revise & resubmit, the work was finally published on the JIFMIM volume 53 in March 2018 [1].

The second essay is motivated by the recent European sovereign debt crisis, which showed how banks' large exposures to distressed governments could lead to instability in the banking system. Large exposures could give rise to a 'bank-sovereign nexus' or a 'doom loop' between governments and the banking system (Acharya et al., 2014; Cooper and Nikolov, 2013; Farhi and Tirole, 2016). For instance, banks with large exposures to distressed sovereigns may respond by cutting lending, which causes slower economic growth, which in turns increases further the sovereign's distress. The impact of the distress experienced by certain sovereigns during the Euro Area sovereign debt crisis on the banking system may have been more pronounced because the regulatory requirements on banks' sovereign exposures were very low (European Systemic Risk Board, 2015). For example, banks are not required to have any capital against the credit risk they face with their exposures to EU sovereigns

[1]DOI: https://doi.org/10.1016/j.intfin.2017.09.017

irrespective of the risk those sovereigns may default. Regulatory limits on the size of exposures a bank can have to a counterparty exempt exposures to sovereigns. And until 2017, banks were not required to deduct fully from regulatory capital losses incurred on sovereign exposures held in the available for sale part of their balance sheets.

The links between sovereign exposures and bank lending have been explored in a number of papers (Gennaioli et al., 2014a,b; Popov and Van Horen, 2015; De Marco, 2016). However, those papers do not provide clear evidence on the channels through which the sovereign shock could be transmitted to the banking system. In addition, existing literature might have missed a potential nuance to how banks' are exposed to sovereigns: sovereign exposures can be found in different parts of the balance sheet with distinct accounting treatments, and related regulatory treatments. One of the key differences in accounting treatment according to where in the balance sheet an exposure is located is the approach to valuing an exposure. Some exposures are valued according to their value when they were created ('historical cost' basis), while others are valued according to their current market value ('fair value' basis). Some have put forward theories for why fair value accounting can increase instability in the banking system Cifuentes et al. (2005); Allen and Carletti (2008); Heaton et al. (2010). Thus, the second essay answers the following research questions:

1. Can a sovereign shock negatively affect banks' lending activity?
2. Through which channel a sovereign shock can destabilise the banking sector (capital channel or funding channel)?
3. Can the accounting and regulatory treatments of sovereign exposures affect the strength of transmission of the sovereign shock?

This essay is developed based on a research project at the Prudential Policy

Directorate, Bank of England when I was doing summer internships at the Bank in 2015 and 2016. Thus, this work is co-authored with my previous colleagues at the Bank and I contributed at least 33% of the work. It is expected that another version of the work would be published on the Bank of England Staff Working Paper Series in late 2018. The output of this essay may produce guidance on how the regulatory treatment on banks' sovereign exposures should be specified in the future macro-prudential policy framework.

The third essay is motivated by a long on-going debate on the relationship between banking competition and financial stability which has been further intensified by the 2007-08 global financial crisis. On one hand, the competition-fragility hypothesis argues that in a more competitive environment banks would lose their "charter value" thus are more likely to shift risk towards depositors with the deposit insurance policy, while in a less competitive environment banks tend to have higher profit and also more capital buffer, thus are not likely to take excessive risks which could endanger the whole financial system (Keeley, 1990; Beck et al., 2006; Berger et al., 2009; Beck et al., 2013).

On the other hand, the competition-stability hypothesis argues that there is a positive relationship between bank competition and financial stability, rather than a trade-off. Lower lending rates resulted from higher level of bank competition reduces borrowing cost for both firms and individuals, and this in turn would reduce banks credit risk. Thus, the banking system as a whole would be more stable in a competitive environment (Schaeck et al., 2009; Anginer et al., 2014). In addition, it is also possible that there is an U-shaped relationship between competition and stability. For a less competitive banking system, more competition would be preferred due to increased efficiency and stability, but if the system is already highly competitive, further increase in competition might induce excessive risk taking which threatens the stability of the system. Therefore the effect of competition on stability could go either way depending on where the banking system is located on the U-shaped curve (Martinez-Miera and Repullo, 2010; Hakenes and Schnabel, 2011). Overall, both theoretical models and empirical evidence provide mixed results. Using a solid empirical setup, the third essay aims to address the following issues:

1. Can banking stability be improved by a positive competition shock in the banking sector?

2. Is the effect of banking competition on banking stability non-linear?

3. Is there any heterogeneity among banks in response to a higher level of competition?

These may help regulatory authorities to balance between policies on facilitating competition in the banking sector and those on maintaining stability of the financial system.

1.2 Overview of the Thesis

The thesis is structured as follows. Chapter 2 presents the first empirical essay which identifies the cross-border bank ownership linkages as an international transmission of liquidity shocks. Following Chapter 2, the second empirical essay presented in Chapter 3 examines the mechanism on how sovereign distress event would have an impact on banks with exposures to the distressed sovereigns. Then, Chapter 4 presents the last empirical essay which provides evidence on the relationship between banking competition and banking stability. Chapter 5 concludes the thesis by summarising the findings from the three essays, providing policy implications, and proposing future scopes of research.

A common feature among the three essays in the thesis is that the identification strategies in these essays are all based on the Different-in-Differences (DID) method, with specific alterations for the three research topics: the first essay exploit the liquidity crisis in the banking systems in Greece, Ireland, Italy, Portugal, Spain (GIIPS) during the sovereign debt crisis as an experiment to implement the DID method, to identify whether the liquidity shocks in GIIPS countries were transmitted to other European countries through bank ownership linkages; the second essay applies the DID method by using the sovereign shocks indicated by sovereign downgrades during the European sovereign debt crisis, to examine how a sovereign shock would have an impact on banks' lending activities; the third essay takes the advantage of the staggered timing of the banking deregulation in the U.S. during the 1980s to implement the DID method, and identifies whether the intensified competition induced by the deregulation would affect banking stability.

Though the identification methodologies are similar across the three essays, the data for the empirical analysis in the three essays are collected from three distinctive sources. The main datasets analysed in the first essay are collected from the Bureau van Dijk Bankscope[2] database which contains historic balance sheet and income statement data for banks across the world. Most importantly, the database provides information on bank ownership at subsidiary bank level, which is essential for the first essay to construct bank ownership linkages across European countries. The second essay also focuses on European banks during the European sovereign debt crisis, however, it takes the advantages of the quarterly frequency of the banking data from the SNL database and the granularity of the sovereign exposure data disclosed by European Banking Authority (EBA) through a series of stress test, transparency exercises and capital exercises since 2010. The third essay turns to focus on the banking deregulation in the U.S. during the 1980s, so the main datasets in the analysis are collected from the Consolidated Reports on Condition and Income (Call report) which provides detailed historic data on balance sheet and income statement for all banking institutions regulated by the Federal Deposit Insurance Company (FDIC).

The rest of this section provides a overview for each essay in the thesis.

1.2.1 Chapter 2 Overview

The aim of this chapter is to examine whether a liquidity crisis spread internationally in accordance with the bank ownership networks. The European sovereign debt crisis that began in 2010 provides an excellent quasi-natural experiment to test possible contagion effects, due to the fact that this shock generated a liquidity crisis in GIIPS countries, plus the banking systems of GIIPS countries are very well interconnected with other European countires through bank ownership linkages. Thus, this study specifically examines how this shock was propagated to the other European countries through ownership linkages of banks and their subsidiaries. Using subsidiary bank

[2]The name of the database has been changed from Bankscope to Orbis Bank Focus by Bureau van Dijk in 2016.

level data collected from the Bankscope Database, it constructs ownership networks for banks located in all European countries. The exposure to the liquidity crisis in GIIPS countries is constructed for each international banking group (network) as measured by the proportion of their total banking assets in GIIPS countries. Then the banking group level exposure is assigned to each bank within the network. For example, a bank is classified as highly exposed to the crisis if the proportion of its group's total assets in GIIPS countries is high. This is an appropriate measure because banks located in a GIIPS country are those most affected by the sovereign shock. Indeed, banks hold more domestic government debts rather than foreign debts on their balance sheet, a phenomenon known as home bias. If there is a sovereign credit event, domestic banks as government bond holders are directly affected.

The primary focus of this study is the performance of the subsidiary banks located in non-GIIPS countries who are connected with banks in GIIPS countries through bank ownership linkages and thus have a positive exposure to the crisis. The working hypothesis is drawn from the theory of capital markets developed by Morgan et al. (2004). Their analysis predicts that banks exposed to a sovereign crisis will reduce their lending during the crisis period in order to support their parent or subsidiary banks. In this essay, it will be the subsidiary banks in non-GIIPS countries with higher exposure to GIIPS countries through their ownership linkages who will reduce their lending. This effect is labelled as the *contagion effect*[3] of the internal capital market in a bank ownership network.

The difference-in-difference (DID) method is implemented to test this hypothesis, where the treatment in the DID setting is a subsidiary bank's indirect exposure to the GIIPS crisis through ownership linkages. The baseline results from the DID regressions imply that a bank's lending growth rate would reduce by 5.75 percent-

[3]This effect is called *support effect* by De Haas and Van Lelyveld (2010).

age points if the bank's exposure increases by 1 percent. The results support the hypothesis that highly exposed banks' lending performance is negatively affected by the foreign liquidity shock due to the cross-border ownership linkages. Furthermore, this study disentangles the transmission effect by exploring the heterogeneity among subsidiary banks in the ownership network. It suggests that larger subsidiary banks and those subsidiaries that were more profitable are found to be more resilient to the shock. It also shows that the parent bank's characteristics affect the transmission of the shock, supporting the notion of an internal capital market operating within these banks. The analysis also shows that subsidiary banks located in Eastern Europe are more fragile when facing a external liquidity shock, compared with those located in Western Europe. This implies that subsidiary banks operating in developing countries tend to be more dependent on liquidity support from their parent banks, as the financial sector is usually less developed in developing countries.

The findings from this chapter build on the existing literature by providing empirical evidence at the level of the banks and their subsidiaries on the operation of an internal capital market with a cross-country setting. Furthermore, it adds to the literature, by including both developed and developing economies in the sample and testing at the bank level whether bank ownership linkages across Europe can serve as a vehicle to transmit liquidity shock.

This chapter also provides several policy implications. First, as a liquidity shock can be transmitted through cross-border bank ownership linkages, regulatory authorities across countries might think carefully about the activities of international banks and whether any of these should be ring fenced. Specific policies targeted at international banks so as to isolate foreign liquidity shocks could help support the stability of a domestic banking system. This is especially important for regulatory authorities in developing countries, as the transmission effect is found to be more pronounced for subsidiary banks located in Eastern Europe. Second, regulators across countries would do better to coordinate their activities and agree policy on an international rather than domestic level. This may help alleviate the potential for contagion across an international bank's internal capital market.

1.2.2 Chapter 3 Overview

Following Chapter 2, this Chapter aims to identify how the sovereign crisis in GIIPS countries could be transmitted to the banking sector which had evolved into a liquidity crisis, with a special focus on the different accounting treatment that these exposures can have. These differences might have important implications, not only to understand the transmission channels from sovereign shocks to bank lending, but also for the design of new regulation. Thus, this chapter specifically investigates whether the accounting treatments of sovereign exposures affected the strength of transmission of the Euro Area sovereign debt crisis onto banks and bank lending. The key difference in accounting standards is between those exposures that are valued on a historical cost basis and those valued on a fair value basis. Loans and government bonds that a bank intends to hold to maturity (HTM) are valued on a historical cost basis, which means that any sovereign distress which falls short of the sovereign defaulting does not change the value of those exposures on a bank's balance sheet. Whereas exposures that are fair valued are valued using current market prices; this means changes in market prices resulting from sovereign distress will reduce the value of those exposures on a bank's balance sheet and create a loss that is deducted from a bank's equity. Bonds that are classified as available for sale (AFS), held for trading (HFT), or under the fair value option (FVO), and derivatives are fair valued.

To identify the the potential adverse effect of those different types of exposure on banking stability, detailed information on banks' sovereign exposure is collected from the disclosure of a series EU-wide stress tests and exercises conducted by the European Banking Authority (EBA) since 2010. These disclosures contain granular data on banks' sovereign exposures, including the information on counterparty countries, residual maturities, accounting classifications. Other bank-level data are collected from the SNL database while sovereign shock indicators and macroeconomic data were collected from Moody's, Bloomberg and Datastream.

In line with previous studies, the analysis shows that negative shocks to sovereign bond are associated to lower subsequent bank lending for banks more exposed to the shocks. Furthermore, it shows that the negative effect of a sovereign shock on bank lending is weaker for better capitalised banks, what is known as the 'capital channel'. It also shows that bank capital matters especially for exposures that are both mark-to-market and subject to no capital requirements, such as available for sale (AFS) exposures: this seems to be the type of exposure through which sovereign shocks are transmitted directly to bank solvency. The capital channel is less important for book-value exposures (held to maturity) and exposures with positive capital requirements (held for trading). It is also revealed that the capital channel is particularly important for short-term exposures (rather than medium- and long-term) and domestic exposures (rather than foreign).

This chapter takes a step further from the previous studies, and provides empirical evidence on how exactly a sovereign shock could be transmitted to banks through the 'capital channel' and the 'funding channel'. Furthermore, this essay also examines the heterogeneity among different types of banks' sovereign exposures with distinctive accounting and regulatory treatment in terms of transmitting sovereign shocks. This issues has not been fully explored in the literature. In addition, this essay also contributes to the literature on the effect of the application of fair value accounting in the banking industry where there is no consensus in the literature yet whether fair value accounting could cause excess negative impact on a bank's financial condition and lending activities.

Chapter 3 also provides some implications in terms of designing regulatory treatment on banks' sovereign exposures in the macro-prudential policy framework. The findings from this chapter suggest that regulatory authorities may need to increase the risk weight on banks' sovereign exposures to make sure banks can weather sovereign shocks without unduly restricting their lending activity. More specifically, the risk weight on banks' sovereign exposures should be determined by the particular level of credit risk of the sovereign. A risk-sensitive risk-weighting framework on banks' sovereign exposure may be essential in protecting banks from sovereign shocks. Furthermore, the risk weight on sovereign exposures should be specifically designed according to the accounting classifications of those exposure, as different accounting treatment can cause different economic consequences.

1.2.3 Chapter 4 Overview

This Chapter turns to explore the relationship between banking competition and banking stability. The U.S. bank branching deregulation in the 1980s provides an opportunity to implement the difference-in-difference (DID) method to identify the causal relationship between the competition shock on banking stability. In the late 1970s, the ability of banks to compete over a longer distance was enhanced by some technological improvement, such as the invention of ATM. As a result, individual states started to deregulated their banking system both intra-state and inter-state branching, which resulted in a higher level of competition in the banking sector. A very important feature of the deregulation is that different states deregulated their banking system at different point in time. Taking advantage of this feature, the

DID method is implemented to address the causality issue. In addition, dynamic DID method also implemented as a robustness check. Following Beck et al. (2013), the banking stability is measured by Z-score calculated with a 3-year rolling window. Furthermore, alternative indicators for banking stability are also adopted in the analysis, such as the inverse standard deviation of ROA and non-performing loan ratio. All these indicators are calculated at both state-level and bank-level. The data for this analysis are collected from the Consolidated Reports on Condition and Income (Call report) which provides detailed balance sheet and income statement data for all banking institutions regulated by the Federal Deposit Insurance Company (FDIC).

The analysis shows that the intensified competition shock caused by the intra-state branching deregulation significantly improves the state-level banking stability. Meanwhile, it shows that the inter-state branching deregulation is estimated to have no significant impact on banking stability at state-level. This baseline result is confirmed by the dynamic difference-in-difference regressions and also the regressions with alternative stability indicators. The bank-level analysis shows consistent result that the intra-state competition shock has a positive and significant effect on the stability of individual banks, which is also robust with the dynamic DID setting and alternative bank-level stability indicators. However, the scale of the estimated effect at bank-level is much smaller.

The unbalanced feature of the bank-level panel dataset may bias the estimated effect of the competition shock on bank-level stability. To examine this issue, both typical DID and dynamic DID regressions are implemented with a balanced bank-level panel dataset. The results from these regressions are qualitatively unchanged compared with the previous findings from the bank-level analysis. Furthermore, it examines the heterogeneity among banks from three perspectives: bank size, bank profitability and the competition environment faced by the bank. It shows that the intra-state competition shock has a greater effect on the stability of small banks, while big banks and more profitable banks are more likely to be affect by the inter-state competition shock. The heterogeneity test also shows that the stability of banks operating in a less competitive environment are more likely to be improved by the inter-state competition shock, which provides evidence on the non-linear relationship between banking competition and stability.

Overall, this chapter builds on the existing literature in two ways. First, it exploits the intensified competition in the banking sector induced by the U.S. banking deregulation as an exogenous shock and identifies the the relationship between banking competition and banking stability with a Difference-in-Differences setting, instead of GMM which is the method exploited by most of the empirical papers in the literature. Second, it provides empirical evidence on the non-linear relationship between banking competition and banking stability predicted by theoretical models, which is a issue that has not been fully investigated in the empirical literature. The policy implication from this chapter is that regulatory authorities may need to develop policies to facilitate effective competition in the banking sector, along with their prudential policies which are specifically designed to maintain the stability of the financial system, because a relative competitive environment in the banking sector may also improve the overall stability of the financial sector.

Chapter 2

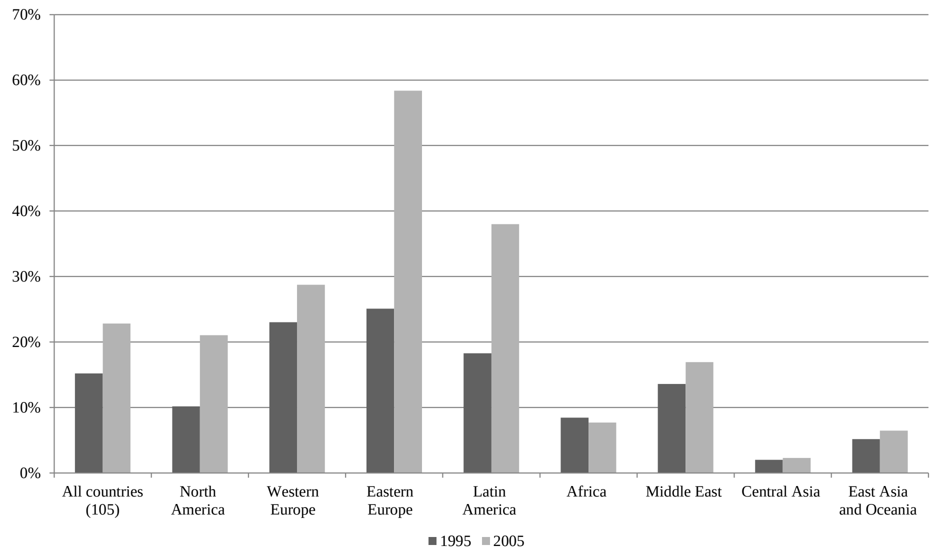
TRANSMISSION OF LIQUIDITY SHOCKS:

Evidence on Cross-border Bank Ownership Linkages

2.1 Introduction

During the past two decades, the globalisation of the world's financial sector has reached an unprecedented level. Banks are internationally connected by both cross-border interbank lending relationship and ownership ties. There has been dramatic increase in the presence of foreign-owned bank in domestic banking system. As Figure 2.1 shows, the overall share of domestic banking assets held by foreign bank increased from 15% in 1995 to 23% in 2005, with large increase in Eastern Europe and Latin America. As a result, the role of foreign banks and foreign-owned domestic banks in a banking system has become more important, in both developed countries and emerging markets.

Figure 2.1: Share of Banking Assets Held by Foreign-owned Bank, by Region



Source: International Monetary Fund (2007)
Notes: This figure shows the trend of the share of domestic banking assets held by foreign-owned bank from 1995 to 2005. As it shows, the overall share increases from 15% to 23%. The the share of foreign bank in Eastern Europe and Latin America increases more significantly than other area, while there is a small decrease of the foreign bank share in Africa.

Yet the implication of an increase in foreign banks are theoretically unclear.

On one hand, the access to foreign banking capital may intensify the competition of the domestic banking industry, stimulate financial innovation, thus improving overall efficiency of the financial sector (Claessens et al., 2001; Sturm and Williams, 2004). In terms of emerging economies, foreign banks from developed countries may provide advanced management techniques for financial institutions and introduce new financial products, services, or business models. These "spillover effects" are helpful for the establishment of a modern financial system and the improvement of financial regulations (Lensink and Hermes, 2004). Positive spill-over effects may be more significant for emerging economies, since King and Levine (1993) suggest that the financial system in developing countries is usually under-developed.

On the other hand, a strong relationship with foreign banks or a large proportion of foreign owned banks in the domestic banking system could be a threat to the financial and economic stability, and the dependence of the banking system on foreign banks creates exposure to any international liquidity crises. For instance, Peek and Rosengren (2000) show that the subsidiaries of Japanese banks in the United States significantly reduced their lending due to the Japanese banking crisis in the 1990s, which had a negative real effect on U.S. economy. In addition, the recent global financial crisis shows that a banking crisis initiated from the United States finally led to the most serious global recession since the great depression, for which the highly globalised financial sector provided the propagation channel (Aiyar, 2012; Cetorelli and Goldberg, 2011).

The aim of this work is to test whether the liquidity crisis spread internationally in accordance with the bank ownership networks. The European sovereign debt crisis provide us a natural to work on this issue due to the fact that it led to a serious liquidity crisis in GIIPS countries (Greece, Ireland, Italy, Portugal, Spain), and that the banking system of GIIPS countries are very well interconnected with other European countries through bank ownership linkages. Though the European debt crisis is seen as a legacy of the 2008 global financial crisis, it was still a prominent shock to the GIIPS countries' banking system, which further deteriorated the economic recession in the wider European area.

Specifically, this study tests whether the liquidity shock to the GIIPS countries' banking system were transmitted to other European countries through the banks' cross-border ownership linkages. To do this, subsidiary bank level data are collected to construct ownership networks for banks located in all European countries. The exposure to the liquidity crisis in GIIPS countries is measured for each international banking group (network) according to the level of their banking activities in GIIPS countries, which is captured by proportion of their total banking assets in GIIPS countries. Then the banking group level exposure is assigned to each bank within the network. For example, a bank would be highly exposed to the crisis if the proportion of its banking group's total assets in GIIPS countries is high. The reason why bank's exposure could be measured in this way is that banks located in a GIIPS country are those most likely affected by the sovereign shock, since banks tend to hold more domestic government debts rather than foreign debts in their balance sheet (home bias effect). Once there is a sovereign credit event, domestic banks as government bond holders would be directly affected.

Thus, the primary focus of this study is on the performance of the subsidiary banks located in non-GIIPS countries who are connected with banks in GIIPS countries through bank ownership networks and thus have a positive exposure to the crisis. The working hypothesis is developed based on the theory of internal capital market proposed by Morgan et al. (2003). Their analysis predicts that bank's with positive exposure to the crisis would reduce their lending during the crisis period to support their parent or peer subsidiary banks in GIIPS countries who is suffering from the sovereign shock. It labels this transmission mechanism as the contagion effect of the internal capital market.[1] To summarise, the hypothesis of this study is that the subsidiary banks in non-GIIPS countries with higher exposure to the crisis will reduce their lending more than those with lower exposure during the crisis.

The difference-in-difference (DID) method is implemented to test this hypothesis. The conventional DID method requires two groups: control group and treatment group; and two periods: pre-period and post-period. In this study, the treatment is the exposure to the crisis, so the control group here contains non-GIIPS subsidiary banks that are not exposed to the GIIPS crisis, while the treatment group includes those subsidiaries who are exposed to the crisis. The year of 2010 is defined as the first year of post-period as usually defined by the literature (Popov and Van Horen, 2013); moreover there is a clear discontinuity in the the CDS spread for GIIPS countries in that year. Thus the pre-period is 2008-2009 and the post period is 2010-2013. Preliminary results from the DID regressions show that the interaction between treatment (exposure) and post dummy is negative and statistically significant, which is very consistent across models with different specifications. This implies that subsidiary banks that are highly exposed due to the ownership linkages would significantly reduce their lending during the crisis period, even if they are not directly exposed to the crisis. The magnitude of the negative effect is large: if the bank's exposure increase by 1 percent, then the bank's lending growth rate would reduce by 5.756 percentage points.

A dynamic DID setting is also applied, which aims to observe the behaviour of the treated group over the sample period. Results show that the interaction between treatment and the year dummy of 2009 (pre-period) is not significant, but the interaction term with dummies for 2010, 2011, 2012, and 2013 is negative and significant. This seems to confirm the results from the conventional DID regressions

[1] This effect is called support effect by De Haas and Van Lelyveld (2010).

that highly exposed banks' lending performance is negatively affected by the foreign liquidity shock due to the cross-border ownership linkages.

Furthermore, this study tries to disentangle the transmission effect by looking at bank heterogeneity. First, it examines the heterogeneity in subsidiary bank's characteristics. The following 5 dimensions are tested: bank size (log of total assets), funding structure (proportion of deposit funding), profitability (ROA), risk attitude (capital and liquidity), and capability in their core business (interest margin and bank weakness). Explanatory regressions show that smaller, more capitalised and less profitable subsidiary banks are more likely to be affected by the foreign liquidity shock, as the negative effect of exposure due to the cross-border ownership linkages are more significant for these banks. Second, it also tests the heterogeneity in parent bank's characteristics. The regression results show that the liquidity crisis is more likely to spillover internationally if the parent bank is more risk-averse, less capable for its core business, or has higher profitability.

The rest of this chapter proceeds as follows. Section 2.2 reviews the related literature on banking networks and the potential for shocks to transmit through the banking system. Section 2.3 describes the empirical framework, including how to use the information on ownership and construct the measurement on exposure to the sovereign crises. Section 2.4 presents descriptive statistics before explaining the DID method in Section 2.5 which generates the results in Section 2.6. Section 2.7 aims to establish robustness before Section 2.8 concludes.

2.2 Literature Review

There is an ample literature investigating banking networks; following Allen and Babus (2009) it can be categorised into two broad areas: network effect and network formation. The former focuses on the financial contagion caused by the interbank lending relationship within the banking system. Allen and Gale (2000) introduce a framework for analysing network resilience to contagion. Based on the liquidity preference model proposed by Diamond and Dybvig (1983), they constructed a simple banking system with four banks exchanging their deposit to others to insure against random liquidity shocks. This makes the system exposed to contagion since if a bank fails other banks cannot liquidate their liabilities (deposits) by the failed bank easily. It follows that in a complete network where banks are all connected with each other, if one bank meets a liquidity problem, everyone just takes a little loss by sharing the shock through the network thus the contagion effect is very small. On the other hand, in a poorly connected network where banks are rarely linked with each others by interbank lending, a failure of a bank may drive the whole system to collapse, due to serious financial contagion. Iyer and Peydro (2011) empirically show that the interbank lending linkage has a contagion effect. They use the failure of a big Indian bank due to fraud as a quasi-natural experiment, and suggest that interbank exposure to the failed bank has a negative effect on banks deposit growth, and the effect is smaller for banks with more solid fundamentals.

The second strand of research looks at the formation and evolution of the interbank lending network. Hale (2012) constructs a global interbank lending network for 7938 banks from 141 countries by using syndicated loan database, and studies the dynamics of this network. The empirical results suggest that recessions and banking crises have a negative effect on the formation of new interbank lending connections. This has an important implication that economic and financial shocks can change the structure of the interbank lending network, thus it may be inappropriate to model the network as static when analysing effects of financial shocks. All these literatures explore the effect and formation of the interbank lending network as a broad concept, yet this study focuses on the international contagion effect induced by bank's cross-border ownership networks. However, there is evidence suggesting that an bank ownership network may intrinsically be a subset of an interbank lending network, since banks within a banking group operates internal capital market to maximise the return on their banking assets.

The banking literature has explored the role of the internal capital market within a banking group. This literature provides a theoretical grounding as to why a liquidity shock can be transmitted through bank ownership linkages. Using US bank data provided by the Federal Reserve Y-9 tapes and the Federal Reserve Reports of Income and Condition (Call Report) from 1986-1989, Houston et al. (1997) suggest that there is an internal capital market established by the bank holding company allocating scarce capital resources among the subsidiary banks. Morgan et al. (2004) examine the effect of the integration of the US banking system during economic volatility. The empirical results support the idea of an internal capital market, through which inter-state banks smooth business cycles. Furthermore, there is evidence for multinational banks; for instance, Cetorelli and Goldberg (2008) suggest that the parent bank and its foreign subsidiary often borrow and lend through their internal capital market; they show that large global-oriented banks in the US use the internal capital markets with their foreign subsidiaries to smooth domestic liquidity shocks. De Haas and Van Lelyveld (2010) construct a network for 45 large multinational banks and their foreign subsidiaries. They support the hypothesis that there exists an internal capital market within international banking groups, and that there is a positive relationship between a parent bank's financial strength and a subsidiary bank's loan growth.

Along side these benefits of being part of a bank network, there is the risk that the foreign subsidiary banks are too dependent on its parent, especially for subsidiaries located in emerging markets where capital is relatively scarce and expensive, and alternative funding sources are more difficult to find. In this case, a liquidity shock received by a parent bank can be ultimately transmitted to its vulnerable foreign subsidiaries through an internal lending channel. Using the Japanese banking crisis in 1990s as a quasi-natural experiment, Peek and Rosengren (2000) show that Japanese banks in the US significantly reduced loan supply during the crisis and this loan supply shock had a negative real effect on economic activities since demand for loans cannot easily be fulfilled with alternative forms of financing. Looking at the recent global financial crisis, Aiyar (2012) uses UK quarterly bank-level data from the Bank of England to show that an external funding shock had a significant and substantial impact on domestic lending activities. Specifically, the evidence suggests that subsidiaries and branches of foreign banks tighten their credit supply more than domestic banks during the crisis.

Other researchers focus their attention on whether and how an economic shock erupted in developed countries could be transmitted to emerging economies. Cetorelli and Goldberg (2011) examine the transmission of liquidity shocks between developed countries and emerging countries in Europe, Asia, and Latin America, by using aggregated country-level data from Banks for International Settlements(BIS). Their results suggest three channels spreading the shock to emerging markets: first, a decline of foreign banks' direct, cross-border credit supply; second, a decline of lending by domestic subsidiaries of foreign banks; and third, a decline of lending by domestically owned banks which are affected by the tight cross-border interbank lending market during the crisis. Popov and Udell (2010) examine whether the recent global financial crisis which erupted in advanced economies was transmitted to central and eastern Europe through foreign banks. They construct an index to measure the level of financial distress in the 14 countries in the region and exploit the data on SMEs provided by the 2008 Business Environment and Enterprise Performance Survey. The results of this study imply that SMEs in central and eastern Europe would have a higher probability of rejection on their loan applications if the banking system was dominated by foreign banks. Another study on Eastern European countries by Ongena et al. (2015) support these results. It is shown that during the recent financial crisis, internationally-borrowing local banks and subsidiaries of foreign banks reduce their loans more than locally funded banks, while lending by banks with more retail deposits are relatively stable no matter whether the banks are foreign-owned or borrowing internationally.

Schnabl (2012) exploits the 1998 Russian default to examine how a liquidity shock received by international banks was transmitted to Peru. Taking advantage of detailed interbank lending databases provided by the central bank of Peru, the author shows that the liquidity shock was transmitted through an international interbank lending channel. Compared with locally funded banks, both internationally borrowing banks and foreign owned banks are affected more by this channel. Specifically, foreign owned banks perform relatively better than those borrowing abroad, since international banks reduce their interbank lending to these banks more than their foreign subsidiaries. Anginer et al. (2014) examine the association of default risk between international parent banks in developed countries and their subsidiaries in emerging economies during the recent financial crisis, rather than transmission channels of the liquidity shock. Controlling for different financial regulation across different countries, they show a significant and positive correlation between a parent's and a subsidiary's default risk. Moreover, it shows that the default risk of subsidiaries with higher capital, retail deposits, profitability and independency is less correlated with the parents' default risk.

The above papers focus on a liquidity shock in a single country transmitted into another country (Peek and Rosengren, 2000), or a global liquidity shock transmitted to a single country (Aiyar, 2012). This essay builds on these papers by providing evidence at the level of the banks and their subsidiaries on the operation of an internal capital market with a cross-country setting. A prior cross-country analysis (Cetorelli and Goldberg, 2011) examines whether a liquidity crisis in advanced economies could be transmitted to emerging markets through foreign banks at country level. This essay adds to this work, by including both developed and developing economies into the sample and testing at the bank level whether bank ownership linkages across Europe can serve as a vehicle to transmit liquidity shocks. This proposition has yet to be tested in the literature.

2.3 Empirical Setting

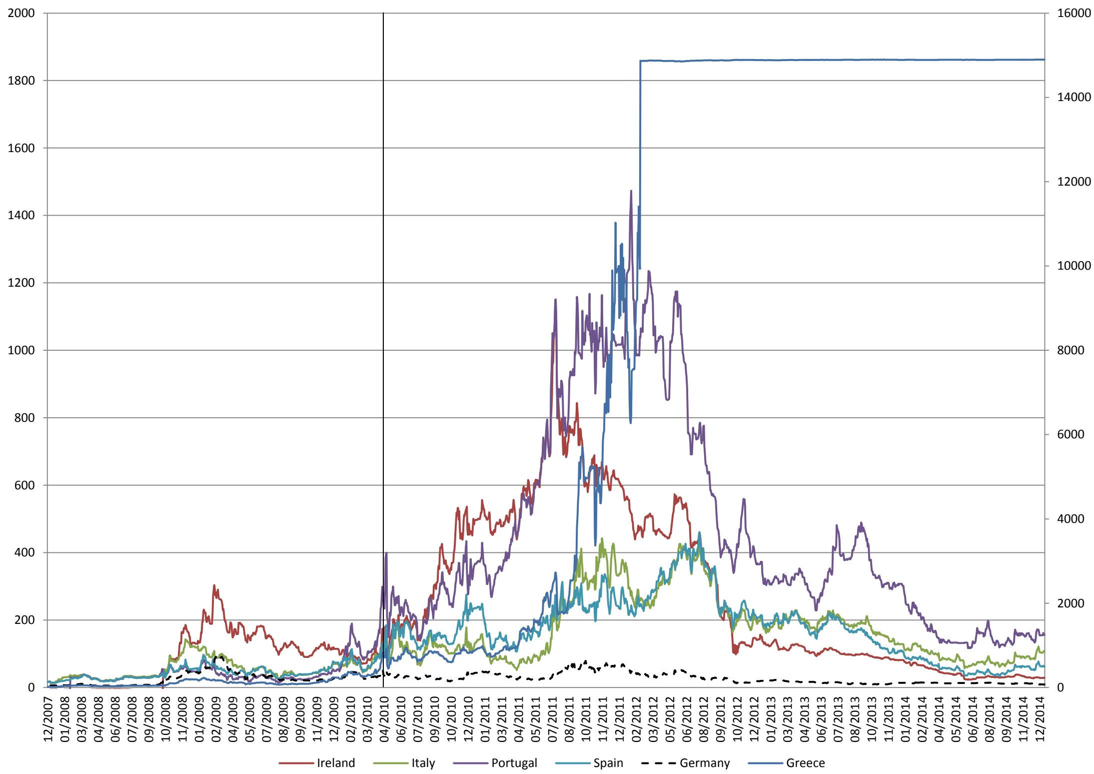
2.3.1 The Crisis as an Experiment

This study tests whether a liquidity shock could be transmitted internationally through a cross-border bank ownership network. The European sovereign debt crisis provides a unique opportunity to work on this issue. In December 2009, Fitch, Moody's, and S&P downgraded the rating for Greek sovereign credit when they perceived that the Greek government was suffering from public deficit difficulties. During April 2010, Greek bonds were downgraded to junk status by S&P. This event is typically regarded as the start of the sovereign debt crisis in Europe. Immediately after, Moody's downgraded the rating for the Irish sovereign debt, and Spain lost its top credit rating. The crisis further deepened in 2011 when Portuguese and Italian sovereign debt rating were downgraded.

Figure 2.2 depicts the CDS (Credit Default Swap) spread of GIIPS countries' 5-year sovereign debt, along with the CDS spread of German 5-year bond as a comparison. A CDS is a financial arrangement by which the buyer of the CDS will be protected by the seller in the event of credit default. Thus, the CDS spread for sovereign indicates the default risk of the sovereign debts, so Figure 2.2 describes the evolution of the sovereign debt crisis. As it shows, after the Greek bond was downgraded to junk status in April 2010, the sovereign crisis formally erupted and the CDS spread of all GIIPS countries started to scramble up and peaked at the beginning of 2012, while the CDS spread of German bonds remained low and stable during the whole period.

Banks holding downdgraded bonds may begin to suffer liquidity issues. As Popov and Van Horen (2015) and De Marco (2013) suggest, there may be two channels through which the valuation haircut on the GIIPS sovereign debts have a negative

Figure 2.2: CDS Spread of GIIPS Sovereign Debts (5 Year), by Country

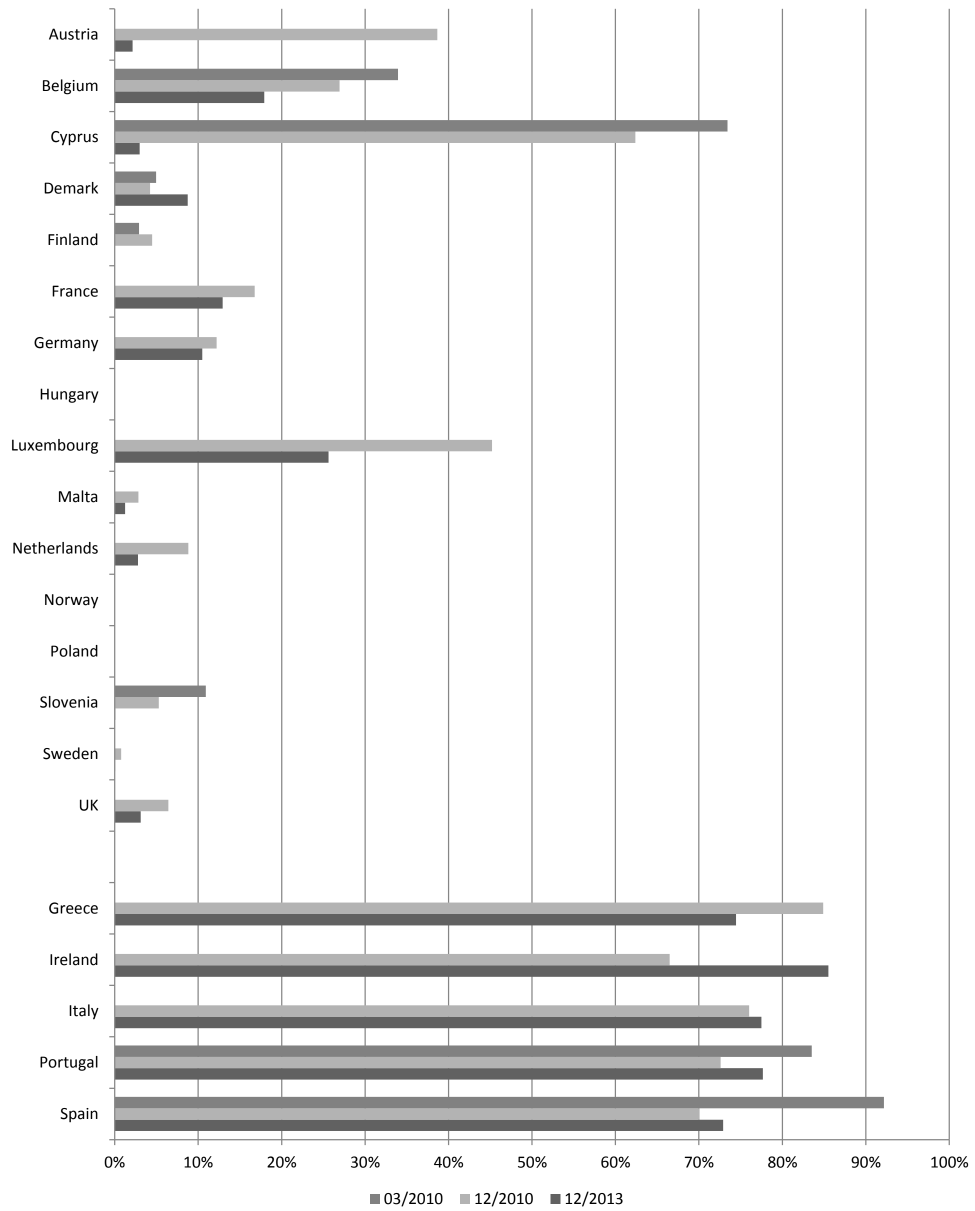


Source: Datastream
Notes: This figure depicts the CDS spread of GIIPS sovereign debt which captures the default risk of the government, thus describes the evolution of the sovereign debt crisis. The unit for Greek debt's CDS spread is depicted by the vertical axis to the right. As it shows, after the Greek bond was downgraded to junk status in April 2010, the sovereign crisis formally erupted and the CDS spread of all GIIPS countries started to scramble up and peaked at the beginning of 2012, while the CDS spread of German bonds remained low and stable during the whole period. The CDS spread for Greek bank remained constant since 2012 as the trading for the products had been suspended.

effect on a bank's liquidity and thus lending activities. These are the 'funding channel' and 'capital channel'. Banks are likely to be affected by a sovereign credit event through the funding channel because the value reduction of the sovereign debt directly weakens the asset side of the bank's balance sheet, and also affects the bank's borrowing capacity in the interbank lending market due to the fact that banks often use sovereign debt as collateral. They are also likely to be shocked through the capital channel because the capital loss due to the devaluation of sovereign debt may drive a bank's capital ratio below the regulatory ratio. In response, the bank reduces lending to maintain their capital ratio. Therefore, the sovereign debt crisis can be seen as a liquidity shock for banks who were holding a relatively large amount of impaired sovereign debts in their portfolio. Since banks usually tend to hold more domestic sovereign debts rather than foreign government bonds (an effect known as home bias), the GIIPS sovereign debt crisis represents a severe liquidity shock to banks located in GIIPS countries.

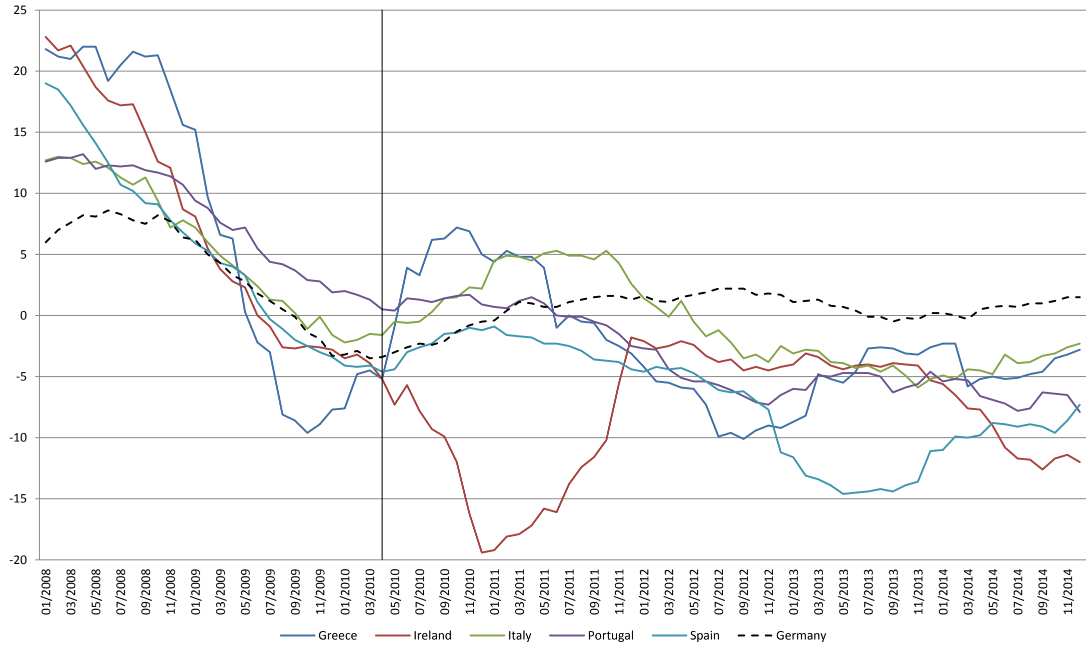
Figure 2.3 shows the overall GIIPS sovereign debt holdings for 21 EU banking systems, as recorded by the European Banking Authority (EBA) stress test in 2010, 2011 and 2014. The tests selected banking groups to cover at least 50% market share of a country's banking system. Though it is not a complete survey for all the banks in the sampled countries, the result is the best proxy available for the European banking system. As the figure shows, excluding GIIPS Countries, Austria, Belgium, Cyprus and Luxembourg had a relative high exposure to GIIPS sovereign debts in 2010. Significantly, banks in these countries reduced their GIIPS debt holdings during the crisis. Meanwhile, the portfolio of GIIPS banks contains a consistent home bias over the same period. Thus if the valuation haircut of sovereign debt has a negative effect on a bank's liquidity, it is very likely that banks in GIIPS country had received the strongest liquidity shock due to the crisis.

Figure 2.3: GIIPS Sovereign Debt Exposure, by Country



Source: European Banking Authority, Stress Test 2010, 2011 and 2014
Notes: This figure shows to what extent a banking system of a EU country was exposed to GIIPS sovereign debts, which is revealed by the EBA stress tests. As it shows, despite GIIPS countries, banks in Austria, Belgium, Cyprus and Luxembourg were highly exposed to the GIIPS debts in 2010. However, those banks significantly reduced their GIIPS debt holding during the crisis. Meanwhile, the sovereign debt portfolio of banks in GIIPS countries performed a consistent home bias. Data for Austria, Germany, France, UK, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Poland, and Sweden in March 2010 is missing.

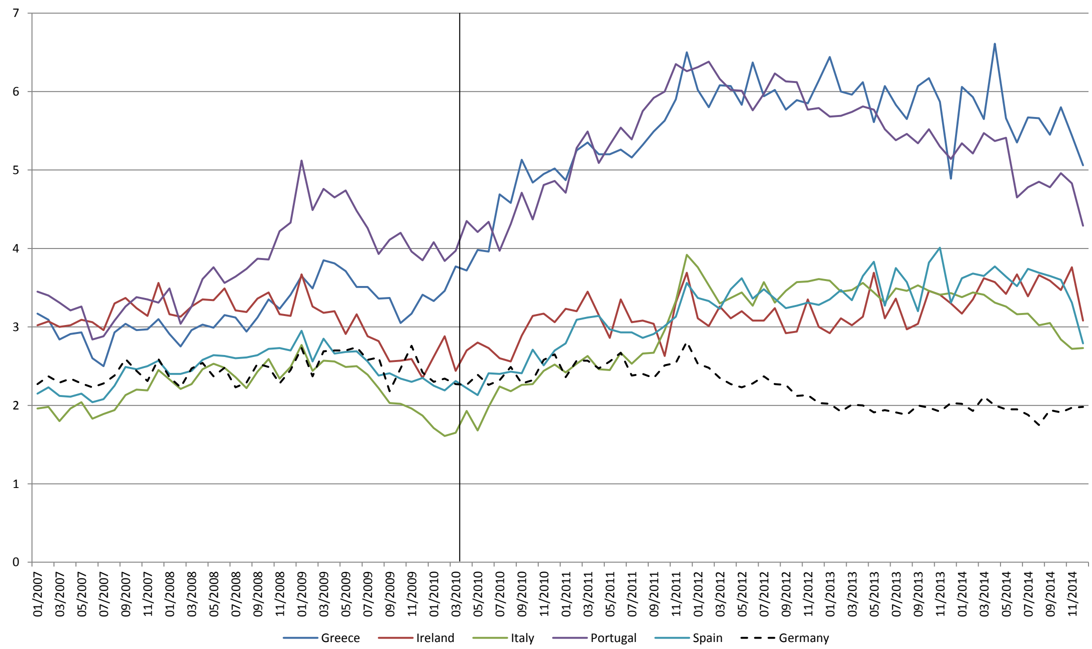
Figure 2.4: Growth Rate of Loans to Domestic Non-Financial Corporations, by Country



Source: European Central Bank Data Warehouse
Notes: This figure presents the loan growth rate to domestic non-financial companies for GIIPS countries and Germany. Banks in all GIIPS countries and also Germany reduce their lending significantly during the global financial crisis in 2008. In the beginning of 2010, banks in all countries tend to recover their credit supply. However, the trends start to diverge when the sovereign shock comes up in April 2010. Growth rate of bank lending in GIIPS country shrinks again during the crisis while German banks increase their lending with a low but stable rate.

Figure 2.4 illustrates the trend of bank credit supply in GIIPS countries and Germany during the crisis period. The growth rate of bank lending fell sharply during the 2008 and 2009 due to the global financial crisis. This can be interpreted as a common trend before the sovereign debt crisis. At the beginning of 2010, banks in all countries show a recovery of their credit supply. However, the trends start to diverge when the sovereign shock comes in April 2010. The growth rate of bank lending in GIIPS country shrinks again during the crisis while German banks increase their lending with a low but stable growth rate. It is worth noting that the poor performance of German banks might also be partly due to the crisis in

Figure 2.5: Interest Spread (on ECB deposit facility) for New Loans to Non-Financial Corporations, by Country



Source: European Central Bank Data Warehouse
Notes: As this figure shows, the interest spread in GIIPS countries start to rise up after the shock while the spread in Germany is relatively low and stable during the crisis period. Together with figure 4, evidence shows that there is a liquidity squeeze in banking system of GIIPS countries during the sovereign debt crisis.

GIIPS countries. In addition, Figure 2.5 shows the interest spread on the policy rate for new loans for the same countries from 2007 to 2014. The story is similar, the trends started to diverge as the crisis occurs. Overall, the evidence shows that banks in GIIPS countries appear to have suffered from liquidity problems during the crisis period, and this can be attributed to the sovereign debt crisis. This study tests whether the liquidity shock on the banking systems in GIIPS countries were transmitted to other European countries through the cross-border bank ownership network in Europe.

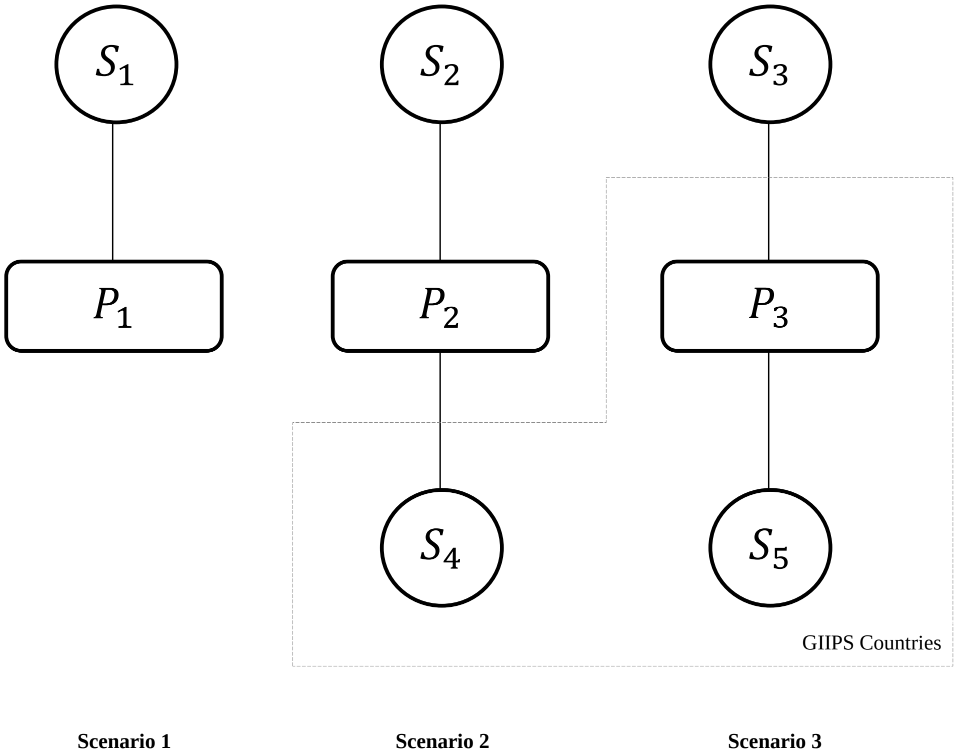
2.3.2 Network Construction and Exposure Measurement

This study constructs ownership networks for banks located in all European countries to examine whether the liquidity shock in GIIPS banking systems was transmitted to other banks through ownership linkages. Ownership networks connect banks in GIIPS countries with banks in other European economies which are not directly exposed to the impaired sovereign debts. An effective ownership linkage between a parent and a subsidiary bank is defined by a control stake where the parent bank holds 50% or more of the subsidiary bank's total equity. Figure 2.6 provides an illustration of the three possible scenarios of the network. Scenario 1 shows the case that both the parent bank P_1 and the subsidiary bank S_1 are located outside of GIIPS countries, so this banking group has no linkages with banks in GIIPS countries thus they do not have any direct exposure to the liquidity crisis in the GIIPS banking system. In scenario 2, one of the two subsidiary banks S_4 is located in a GIIPS country, thus there is a possibility that the liquidity shock received by S_4 could be transmitted to the parent bank P_2 and the other subsidiary S_2. The last possible scenario is that the parent bank is located in GIIPS country. As scenario 3 shows, the parent bank P_3 and subsidiary bank S_5 are located in GIIPS countries while the other subsidiary bank S_3 is located in other economies. In this scenario, it is plausible that the liquidity shock in GIIPS countries may have an effect on S_3 since it has a relatively large exposure.

The main objective of this study is to test whether the liquidity shock received by either S_4, S_5 or P_3 would be transmitted to S_2 and S_3, respectively, through cross-border ownership linkages. In other words, it focuses on whether subsidiary banks S_1, S_2 and S_3 behave differently during the crisis due to the ownership linkages with banks in GIIPS countries.

It is necessary to identify the degree of exposure to the crisis based on the

Figure 2.6: Three Scenarios of Bank Ownership Network



Notes: This figure illustrates 3 possible scenarios of bank ownership network in this study. P_i stands for parent banks and S_i stands for subsidiary banks. Scenario 1 is the case that both parent banks and subsidiary bank are located in non-GIIPS countries thus this banking group is not exposed to the crisis. Scenario 2 shows that one subsidiary of the banking group is located in GIIPS country thus there is a possibility that the liquidity shock received by S_4 could be transmitted to the parent bank P_2 and the other subsidiary bank S_2. The last possible scenario is that the parent bank is located in GIIPS country. In this case, it is very likely that the liquidity shock received by the parent bank would be transmitted to S_3 through the ownership linkage.

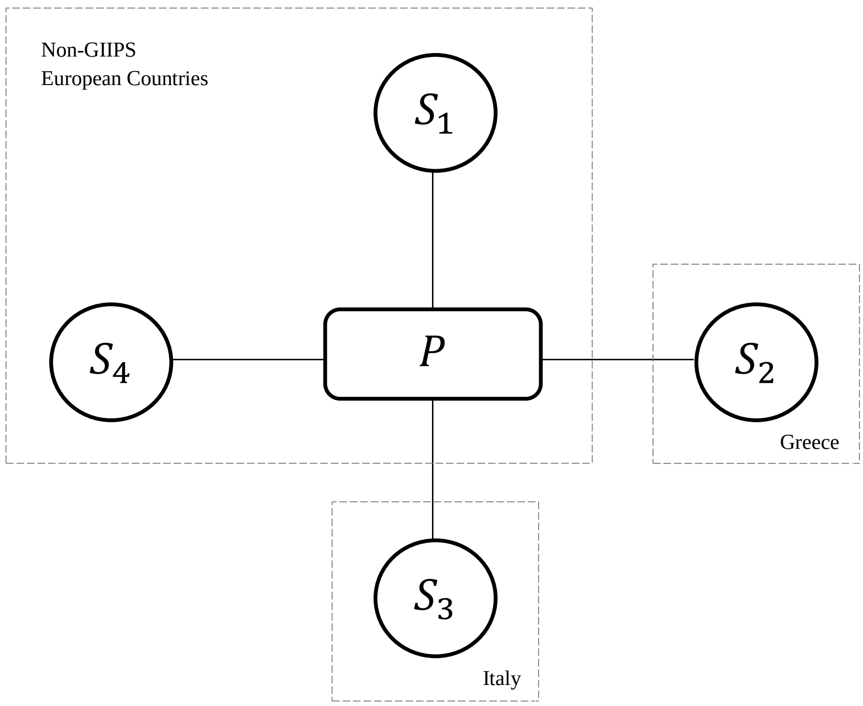
identified cross-country bank ownership networks. In order to do this, an exposure measurement is constructed at the banking group level, indicating the extent to which the subsidiary banks in a banking group are exposed to the crisis. The measurement can be given by the equation below

$$Exposure_{it} = \sum_k \frac{Assets_{ikt}}{Total\ Assets_{it}} \times CDS_{kt}$$

where i identifies the banking group, t denotes time point and k stands for each

GIIPS country. $TotalAssets_{it}$ is the total assets of the parent banks of the banking group. The first term captures the extent to which the banking groups are involved with the business in GIIPS countries, thus the exposure of the banking group to the crisis. The second term, CDS_{kt} captures the intensity of the crisis in different countries. Therefore the exposure of each subsidiary bank outside of the GIIPS countries is given by the calculated exposure of the banking group.

Figure 2.7: Example of a Simple Network



Notes: This figure illustrates an example of a simple network in scenario 2 where the parent bank P is located in non-GIIPS country.

Figure 2.7 illustrates an example of a simple bank ownership network across European countries, as in scenario 2. The parent bank of this banking business group is located in a non-GIIPS European country, say France, while it has two subsidiaries in GIIPS countries, S_2 in Greece (GR) and S_3 in Italy (IT). There are also two subsidiary banks S_1 and S_4 located in non-GIIPS countries, which could be both domestic subsidiaries in France or foreign subsidiaries in countries like Germany or the UK. The exposure to the crisis for S_1 and S_4 at time t are then given by the exposure of this banking group X at time t:

$$Exposure_{Xt} = \frac{Assets_{S_2 t} \times CDS_{GRt} + Assets_{S_3 t} \times CDS_{ITt}}{Total\ Assets_{Xt}}$$

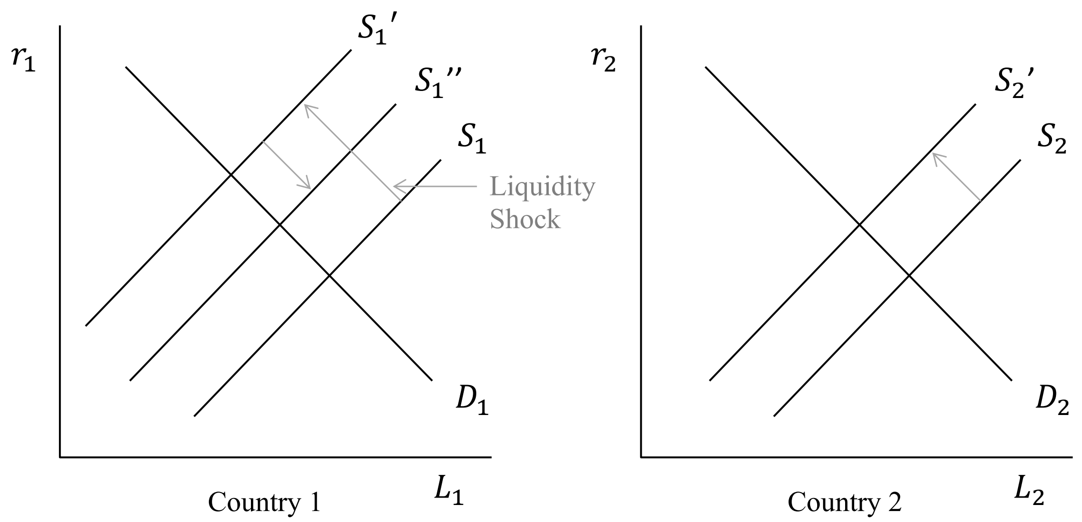
where $Total\ Assets_{Xt} = Assets_{Pt} + \sum_{i=1}^{4} Assets_{S_i t}$

2.3.3 Theory and Hypothesis

Holmstrom and Tirole (1997) propose an incentive model for financial intermediation. This model suggests that the moral hazard problem of firms as a borrower can be alleviated by monitoring from banks, but banks as financial intermediators can neglect to monitor and thus also generate a moral hazard problem to depositors (indirect investors). In this case, banks' loanable funds and firms' investment spending are determined by the stock of bank capital and firm collateral. Both a credit crunch caused by a capital shock on banking system and a collateral squeeze in the real economy can reduce the loanable funds and investment spending. Morgan et al. (2004) extend this model to a two-state version to analyse the effect of inter-state banking on economic volatility in the US during the bank integration process after 1978. The model shows that the effect of a credit crunch in a state can be dampened under the interstate banking regime while a collateral squeeze will be amplified through the internal capital market between banks.

This conceptual framework can easily be extended to the context of multinational banks where there is some non-negative degree of capital mobility between host countries. The application of this model for explaining the effect of multinational banks during the European debt crisis is illustrated in Figure 2.8, with two classical demand-supply diagrams. The X-axis denotes the loan quantity and Y-axis denotes loan rate or bank capital return. Consider country 1 as one of the five GIIPS countries and country 2 as a non-GIIPS European country. The valuation haircut of the GIIPS debts may reduce the liquidity of banks in country 1 through both the capital channel and the funding channel, which shifts the bank credit supply curve to the left, resulting in a lower amount of bank lending and a higher interest rate. This process is supported by the trend of loan growth and interest spread depicted in Figure 2.4 and 2.5.

Figure 2.8: Internal Capital Market Hypothesis



Notes: In the left panel, a liquidity shock at the banking system of Country 1 lead to a lower level of loan supply and a higher loan interest rate. If Country 2 is connected with Country 1 by bank ownership networks, the model predicts that the shock will be alleviated in Country 1 but transmitted to Country 2 in the right panel, through the channel of banking group's internal capital market.

If there is no multinational banking, the story would end here and nothing would happen in country 2. However, country 1 and country 2 are connected by bank ownership networks. Observing higher capital return in country 1, the bank holding company or headquarters will reallocate their banking assets across countries, by reducing their lending in country 2 and increasing credit supply in country 1. The mitigation of the liquidity shock in country 1 due to the internal capital market is called the ‘support effect’ by De Haas and Van Lelyveld (2010), whereas the credit contraction in country 2 is labelled as the ‘contagion effect’ in this essay, since the liquidity shock spills over through the internal capital market. The major objective of this study is thus to identify the contagion effect in the banking system of non-GIIPS countries during the European sovereign debt crisis.

2.4 Data and Descriptive Statistics

In section 2.3.2, a bank is defined as a parent bank's subsidiary if 50% or more of its total equity are directly held by the parent bank. 50% is the natural cutoff which gives the parent bank absolute control over its subsidiary and hence plausibly part of the internal capital market. [2] In order to identify banks ownership ties, it extracts banks' shareholder information from Bankscope and then links parent banks with their subsidiaries.[3] Finally, bank ownership networks across European countries is constructed based on banks' shareholder information in the year of 2010, which is the starting point of the sovereign debt crisis.

Table 2.1 shows the sample of countries used in this study and the number of parent banks and subsidiary banks in each country that could be identified from the data. The data records information for 8,872 banks from which shareholder information could be observed for 709 subsidiary banks belonging to 281 banking groups. The sample is limited to include four types of banks: commercial banks, cooperative banks, mortgage banks, and saving banks. Bank holding companies are initially included in the sample in order to construct the ownership network, as the holding company is the most important node in a ownership network. Once the networks are constructed, bank holding companies are dropped from the sample because they do not function as the other four types of banks that collect deposit and originate loans.

As Table 2.1 shows, 455 subsidiary banks are located in Western European countries while 254 subsidiary banks are based in Eastern Europe. In terms of parent banks, there are 238 banks from Western Europe and 43 banks are located in East-

[2]Additionally, the study also explored whether differences emerge between nearly wholly subsidiaries (90–100% ownership) and majority owned subsidiaries (50–90% ownership). Splitting the sample at this cut-off did not reveal differences between these entities and the results of this exercise are presented in Section 2.7.4.

[3]Some banks' shareholders are also owned by other European banks. In this case, these banks are all defined as the subsidiaries of the ultimate parent banks.

Table 2.1: Sample Country, Parent Banks and Subsidiary Banks

Western Europe			Eastern Europe		
Countries	Parent	Subsidiary	Countries	Parent	Subsidiary
Andorra	1	2	Albania	1	8
Austria	25	42	Belarus	1	7
Belgium	6	16	Bosnia and Herzegovina	0	9
Cyprus	4	7	Bulgaria	1	11
Denmark	12	21	Croatia	1	11
Finland	3	6	Czech Republic	2	9
France	30	91	Estonia	0	4
Germany	35	71	Hungary	2	13
Gibraltar	0	0	Kosovo	0	1
Greece	5	-	Latvia	0	9
Iceland	2	1	Lithuania	1	3
Ireland	2	-	Macedonia	0	8
Italy	15	-	Moldova	0	4
Liechtenstein	1	1	Montenegro	0	3
Luxembourg	7	53	Poland	3	27
Malta	0	2	Romania	1	16
Monaco	1	0	Russia	26	65
Netherlands	11	20	Serbia	0	12
Norway	8	10	Slovakia	0	6
Portugal	3	-	Slovenia	2	6
San Marino	0	1	Ukraine	2	22
Spain	3	-			
Sweden	7	9			
Switzerland	27	46			
Turkey	9	7			
United Kingdom	21	49			
Total	238	455	Total	43	254

Notes: This table shows the sample country for this study and the number of parent banks and subsidiary banks in each country that could be identified from the database thus included into the ownership network. The categorisation between Eastern and Western European countries is classified by Bankscope. Initially Bankscope records information for 8,872 banks in the sample countries, from which shareholder information could be observed for 709 subsidiary banks belonging to 281 banking groups. Subsidiary banks in GIIPS countries are not included in the sample since this study focus on subsidiary banks in non-GIIPS countries only.

ern European countries. Subsidiary banks in GIIPS countries are not included in the sample since this study focus on subsidiary banks in non-GIIPS countries only. However, subsidiary banks are allowed to be owned by parent banks in GIIPS country, in which case the banking group would be in scenario 3 according to the taxonomy of the analysis.

Banks' balance sheet data are also obtained from Bankscope. Bank-level unconsolidated data are collected for 709 subsidiary banks and 281 parent banks, from 2008 to 2013, resulting in an unbalanced panel dataset. GDP growth rate and unemployment rate data for the sample banks' host and home countries are also collected from the World Bank DataBank. Table 2.2 presents the summary statistics for the variables that used in the following econometric analysis.

The key variable of interest in this study is the subsidiary bank's exposure to the crisis. In order to scale the bank's exposure according to the intensity of the crisis, CDS spread data for GIIPS country's 5-year senior debts are collected from DataStream.[4] It takes the average level of sovereign debt CDS spread in December each year to scale the bank's exposure. As a result, exposure becomes a time-varying variable though the ownership network is constant. Since the magnitude of the CDS spread varies remarkably (as the trends in figure 2 suggest), the magnitude of the calculated exposure also varies, hence the logarithm of the final exposure variable is used in order to harmonise the data. Figure 2.9 depicts the distribution of exposure data for banks with positive exposure to the crisis. Grey bars show the exposure distribution for subsidiary banks in scenario 2 where the parent banks are located in non-GIIPS countries, while black bars show the distribution for banks in scenario 3 where their parent banks are located in GIIPS countries. Clearly, banks in scenario 3 tend to have higher exposure than banks in scenario 2, which suggests that the

[4]The trend of the CDS spread for other types of sovereign debts are highly correlated thus the CDS spread for 5-year senior debt is used as the indicator for the crisis intensity.

Table 2.2: Summary Statistics for Main Variables

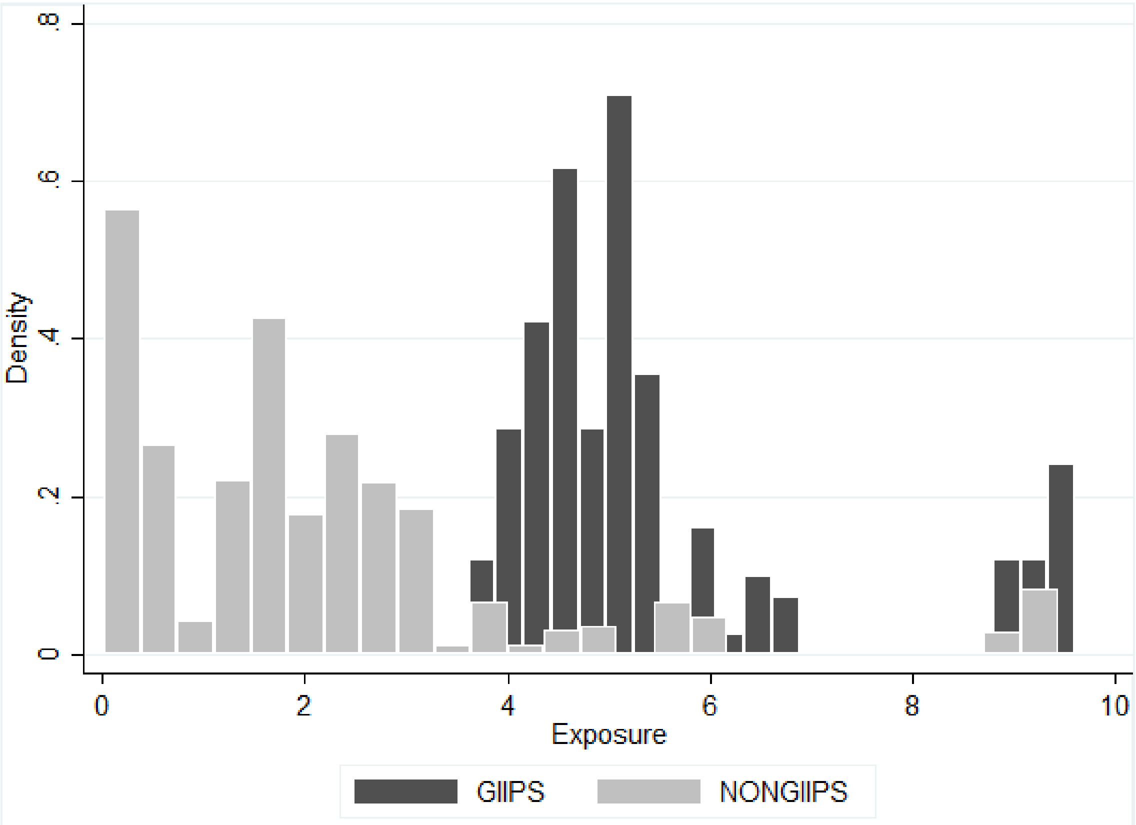
Variable	Bank Type	Mean	Std. Dev.	Min	Max	Observation
Bank Level						
Loan Growth	*Subsidiary*	10.70	54.97	-100.00	900.00	3,001
	Parent	10.68	54.56	-100.00	796.81	822
Size	*Subsidiary*	14.61	2.17	4.22	21.63	3,210
	Parent	16.35	2.23	8.65	21.86	955
Deposit	*Subsidiary*	57.57	31.86	0.00	100.00	3,004
	Parent	53.11	28.20	0.00	100.00	793
Liquidity	*Subsidiary*	28.70	23.33	0.01	100.00	3,205
	Parent	21.33	17.05	0.00	89.37	909
Capital	*Subsidiary*	11.96	13.36	0.25	100.00	3,199
	Parent	22.33	28.93	0.00	100.00	944
Interest Margin	*Subsidiary*	3.05	3.76	-3.95	61.49	3,080
	Parent	2.28	3.04	-25.20	35.20	862
Profitability	*Subsidiary*	0.31	4.62	-94.33	98.21	3,195
	Parent	-0.54	13.62	-233.42	35.56	946
Country Level						
GDP Growth	*Host Country*	0.77	3.40	-17.95	10.20	4,235
	Home Country	0.47	3.11	-14.80	10.20	1,672
Unemployment	*Host Country*	8.07	4.72	2.60	47.50	4,095
	Home Country	7.21	3.29	2.60	27.30	1,634

Notes: This table presents the summary statistics for the variables that used in our econometric analysis. Bank level data are obtained from Bankscope while country level data are collected from World Bank. *Loan Growth* is the annual growth rate of gross loans, including net loans and also loan loss reserves. This variable is used as the performance indicator for bank's lending activities. *Size* is log of a bank's total assets, which is a typical measurement for bank size. *Deposit* is a bank's customer deposit divided by its total assets. *Liquidity* is a bank's liquid assets over total assets, while *Capital* is a bank's total equity over total assets. *Interest Margin* is a bank's net interest margin indicating the bank's capability in its core business. *Profitability* is indicated by bank's return on total assets. *GDP Growth* is the annual growth rate of GDP while *Unemployment* is the unemployment rate for each country in our sample.

exposure measurement works well because banks in scenario 3 are expected to be more exposed to the crisis compared with scenario 2 banks.

Figure 2.10 shows the trends of average loan growth rate for banks in different level of exposure. In the final sample, 525 banks have no exposure to the crisis, thus these banks are in scenario 1. For positive exposure, 97 banks are categorised into low exposure group while 85 banks are categorised into high exposure group, based on the exposure data in 2010. As the figure shows, the lending activity of banks in all 3 types collapsed between 2007-2009 due to the global financial crisis, and

Figure 2.9: Exposure Distribution



Notes: This figure depicts the distribution of exposure data for banks with positive exposure to the crisis. Grey bars show the exposure distribution for subsidiary banks in scenario 2 where the parent banks are located in non-GIIPS country, while black bars show the distribution for banks in scenario 3 where their parent banks are located in GIIPS country. It clearly shows that banks in scenario 3 tend to have higher exposure than banks in scenario 2, which suggests that the exposure measurement works well since banks in scenario 3 are expected to expose more to the crisis compared with scenario 2 banks.

this dynamic can be interpreted as a common trend. However, in the year of 2010, which is the first year of the European debt crisis, banks in scenario 1 and banks with lower exposure experienced a strong recovery in their lending growth while highly exposed banks did not show the same level of recovery. More importantly, the average lending growth rate for banks with higher exposure continues to drop in 2011 with the further deterioration of the European debt crisis, and there is no sign of recovery until 2014. Another thing to be noticed here is that though lending growth for both scenario 1 banks and lower exposed banks has been recovered since

Figure 2.10: Trend of Loan Growt Rate, by Exposure Group

Notes: This figure shows the trends of average loan growth rate for banks with different level of exposure. In the final sample, 525 banks have 0 exposure to the crisis (scenario 1 banks). For those who have positive exposure, 97 banks are categorised into low exposure group while 85 banks are categorised into high exposure group, base on the exposure data in 2010. As the figure shows, the lending activity of banks in all 3 types collapsed between 2007-2009 due to the global financial crisis. In 2010, which is the first year of the European debt crisis, banks in scenario 1 and banks with lower exposure experienced a strong recovery in their lending growth while highly exposed banks did not recover to the same extent. The average lending growth rate for banks with higher exposure continues to drop in 2011 with the further deterioration of the European debt crisis, and there is no sign of recovery until 2014. Though lending growth for both scenario 1 banks and lower exposed banks has been recovered since 2010, the performance of lower exposed banks is much more volatile than scenario 1 banks during the crisis period.

2010, the performance of lower exposed banks is much more volatile than scenario 1 banks' during the crisis period. This suggests that the stability of banks' lending activity would also be affected even they are just marginally exposed to the crisis. It also explored whether the decline in loan growth observed over the sample period varied at points in the distribution other than the mean, but the decline is at all percentiles.

2.5 Econometric Method

It employs the method of difference-in-differences (DID) to identify whether the liquidity crisis in GIIPS country's banking system due to the European sovereign debt crisis could be transmitted to other European countries through bank's cross-border ownership linkages. A conventional DID setting requires two groups: control group and treatment group; and two periods: pre-treatment period and post-treatment period. Two dummy variables will be created to indicate whether an observation gets the treatment or not before and after the implementation of the treatment; and whether this observation is in pre-treatment period or post-treatment period. It tests the difference in the difference between the treated group and control group in the two periods. Thus a significant difference in difference would suggest a significant treatment effect.

Specifically, the treated groups in the DID analysis are the non-GIIPS-based banks exposed to the liquidity crisis in a GIIPS country, due to their ownership linkages with banks in a GIIPS banking system. The control group is represented by banks without an ownership link with banks in the GIIPS countries (e.g. scenario 1). The year of 2010 is used as the cut-off between the pre- and post-period, since early 2010 is considered the sating of the debt crisis. In terms of grouping, in the control group there are 525 (scenario 1), while in the treated sample there are 172 banks with positive exposure (scenario 2 or 3). Note that exposure here is a continuous variable so it can measure the intensity of the shock.

The specifications of the regression model are illustrated by the equations below. It first applies the conventional DID method to find the treatment effect. As equation 2.1 shows, the DID method is implemented by the interaction term between bank's exposure (treatment) and the dummy variable for post-period. The estimated coefficient on the interaction term, $\hat{\alpha}_2$, will examine the hypothesis that the subsidiary banks with higher exposure to the crisis would reduce their lending growth more than those with lower exposure during the crisis.

$$\Delta L_{i,j,t} = \alpha_1 + \alpha_2 Expo_{j,t} * Post_t + \sum_{k=3}^{m} \alpha_k X_{i,t} + \sum_{k=m+1}^{n} \alpha_k X_{j,t} + \gamma_t + \gamma_i + \xi_{i,j,t} \quad (2.1)$$

$$\Delta L_{i,j,t} = \beta_1 + \sum_{k=2}^{p} \beta_k Expo_{j,t} * Year_t + \sum_{k=p+1}^{q} \beta_k X_{i,t} + \sum_{k=q+1}^{s} \beta_k X_{j,t} + \gamma_t + \gamma_i + \epsilon_{i,j,t} \quad (2.2)$$

where

- i stands for each subsidiary bank in the sample;
- j stands for each parent bank/banking group;
- t denotes each year in the sample, ranging from 2008 to 2013;
- $\Delta L_{i,j,t}$ is loan growth rate of subsidiary bank i in banking group j at time t;
- $Expo_{j,t}$ is banking group j's exposure to the crisis at time t;
- $Post_t$ is a dummy variable for post-period which takes value 1 if the time is in between 2010 to 2013; otherwise 0;
- $Year_t$ is time dummy variables, which indicate each year in the sample, ranging from 2008 to 2013;
- $X_{i,t}$ is a set of control variables for subsidiary bank i at time t;
- $X_{j,t}$ is a set of control variables for parent bank j at time t;
- γ_t is time dummy variables controlling for year effect;
- γ_i controls for bank level fixed effect for subsidiary bank i;

- $\epsilon_{i,j,t}$ is the error term for bank i in group j at time t.

This analysis also applies the dynamic DID method in the robustness check section. The conventional DID with two periods can only identify whether the treatment has an effect in the post period, while the dynamic DID allows us to see the impact of treatment as it evolves over the years in the post period. In other words, the advantage of dynamic DID method is that it is able to show when the treatment becomes effective and when the effect dies out. As equation 2.2 shows, the dynamic DID method is implemented by introducing a interaction term between bank's exposure and year dummy variables. The estimated coefficient on this term shows the effect of a bank's exposure on bank lending activity in each year over the sample period, thus the assumption of common trends before the shock can be inspected.

The dependent variable, *Loan Growth*, is the annual growth rate of gross loans, including net loans and also loan loss reserves. As suggested by De Haas and Van Lelyveld (2010), it captures the changes in loan that is due to changes in loan loss provisions. This variable is used as the performance indicator for bank's lending activities. Finally, the following variables is included into the regressions to control for both subsidiary and parent characteristics. *Size* is log of a bank's total assets, which is a typical measurement for bank size. *Deposit* is a bank's customer deposit divided by its total assets. This variable indicates bank's funding stability by capturing to what extent the bank is funded by stable customer deposits. *Liquidity* is a bank's liquid assets over total assets, while *Capital* is a bank's total equity over total assets. *Liquidity* and *Capital* measure a bank's risk aversion and solvency. A higher liquidity/capital ratio indicates that the bank is taking less risk and is more solvent. *Interest Margin* is a bank's net interest margin indicating the bank's capability in its core business. *Profitability* is indicated by bank's return on total assets. Summary statistics for the variables is presented in Table 2.2.

2.6 Empirical Results

2.6.1 Baseline Result

The baseline results of this study are presented in Table 2.3. Columns (1) to (3) show the results from the conventional DID regressions. The first specification does not include any control variables while the second and third specifications include controls for the subsidiary's characteristics and for the parent's characteristics respectively. The number of observations decreases as more control variables are included into to the model. The estimated coefficient on *Exposure* is positive and statistically significant, suggesting that banks with higher exposure tend to have a higher lending growth rate during the whole sample period. However, this effect is not significant once it controls for the characteristics of subsidiary or parent banks, as shown in columns (2) and (3). *Post* dummy has a negative coefficient, indicating that the lending activity of all banks are negatively affected during the crisis, though again it is not significant once it includes control variables for both subsidiary and parent banks. The interaction between *Exposure* and *Post* dummy is the key term in the conventional DID regressions and the estimated coefficient on this term shows the baseline result of the analysis. The coefficient is negative and statistically significant and is consistent across the each specification. Taking the estimate from column (3) as an example, the estimated coefficient implies that if a bank's exposure increases by 1 percent, the bank's lending growth rate would decrease by 5.756 percentage points. The subsidiary bank's exposure is calculated based on the bank's ownership linkages with banks located in GIIPS country where there is a liquidity crisis, thus it captures to what extent the subsidiary bank is exposed to the crisis due to its ownership ties. The regression results then show that the ownership linkages between banks in GIIPS country and bank in Non-GIIPS EU countries transmit the liquidity crisis. In other words, one cannot reject the hypothesis that the liquidity crisis in GIIPS country was transmitted to other European countries through bank ownership networks.

The estimates include a rich set of control variables. These are presented in the second and third columns of Table 2.3. They show that the size of a subsidiary bank is positively and significantly related to the bank's lending growth rate, and the effect is large: if the size of the subsidiary bank increases by 1 percent, its lending growth rate would be 21.9 percentage points higher on average during the sample period; bank liquidity is negatively related with the loan growth rate and this effect is also significant: a 1 percentage point increase in a bank's liquid assets reduce its loan growth rate by 1.4 percentage points; however, subsidiary bank's deposit, capital and profitability are not significantly related with a bank's lending activity during the sample period. Apart from bank level controls, host country's characteristics controlling for country-level demand-effects also have significant effects on bank performance. As to be expected, the subsidiary bank's lending growth is positively related with the host country's GDP growth while negatively related with the unemployment rate. This suggests that the subsidiary banks expand their credit supply faster in those countries where the economy is growing.

The parent bank's characteristics are also important for the subsidiary's lending activity, as suggested by the internal market hypothesis. As the third panel of Table 2.3 shows, the interest margin of parent bank is the only significant factor. Contrary to the findings by De Haas and Van Lelyveld (2010), a parent bank's interest margin is negatively related with tis subsidiary's lending growth. Since interest margin captures a bank's capability in its core business, this result suggests that the subsidiaries of parent banks with better performance tend to have a lower lending growth rate during the sample period. However, this could be explained

Table 2.3: Baseline Results

Dependent variable:	Diff-in-Diff		
Loan Growth	(1)	(2)	(3)
Exposure	5.325**	3.083	7.108
	(2.100)	(2.257)	(4.794)
Post	-12.918***	-7.701*	-5.017
	(2.767)	(4.323)	(6.730)
Exposure*Post	**-5.189*** **	**-3.920** **	**-5.756** **
	(1.476)	**(1.590)**	**(2.354)**
Subsidiary Characteristics			
Size		14.546**	21.892**
		(6.439)	(10.901)
Deposit		-0.109	-0.048
		(0.161)	(0.326)
Capital		-0.420	-0.527
		(0.533)	(0.633)
Profitability		2.779	3.543
		(2.623)	(3.248)
Liquidity		-0.971***	-1.404***
		(0.245)	(0.434)
Parent Characteristics			
Size			-8.077
			(9.466)
Capital			-0.163
			(0.321)
Profitability			0.195
			(0.319)
Liquidity			-0.188
			(0.154)
Interest Margin			-2.301*
			(1.262)
Constant	18.835***	-149.046	-85.719
	(2.252)	(97.619)	(191.716)
Year FE	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Observations	3,001	2,736	1,616
No. of banks	638	590	393
R^2	0.030	0.108	0.158

Notes: This table presents the Baseline results of this study, where the dependent variable is the annual growth rate of gross loans. We do not include any control variables in the first regression while the second regression includes controls for subsidiary's characteristics and then in the third regression we further include controls for parent's characteristics (GDP growth and Unemployment rate are also included in the regressions). *Size* is log of a bank's total assets. *Deposit* is a bank's customer deposit divided by its total assets. *Liquidity* is a bank's liquid assets over total assets, while *Capital* is a bank's total equity over total assets. *Interest Margin* is a bank's net interest margin indicating the bank's capability in its core business. *Profitability* is indicated by bank's return on total assets. The interaction between *Exposure* and *Post* dummy is the key term in the conventional DID analysis. Overall, the estimates from the conventional DID method suggest that the liquidity crisis in GIIPS countries were transmitted to other European countries though bank's cross-border ownership linkages. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

by the internal capital market hypothesis that if the parent bank observe better investment opportunities in the home country, then they would focus more on its own market rather than support its subsidiary banks abroad, thus the foreign subsidiaries would have relatively lower lending growth rates. Besides, the control variables for home country characteristics have no significant effect on a subsidiary bank's lending growth. To summaries, the estimates on the control variables only provide weak evidence on internal market hypothesis.

2.6.2 Bank Heterogeneity

The baseline results suggest that the liquidity crisis in GIIPS countries' was transmitted to other European countries through the banks' cross-border ownership linkages. This section disentangles the transmission effect by looking at bank heterogeneity. In other words, it examines which characteristics of the banks could help subsidiary banks to be more resilient to external liquidity shocks, and which characteristics could instead intensify the propagation of the shock.

To do this, the sample is evenly divided into 3 sub-samples according to different levels of a bank's pre-crisis balance sheet structure as of 2009. For example, in terms of the size of the subsidiary banks measured by log of total assets, the level I sub-sample only includes small banks in the initial sample, while big banks are categorised into the level III sub-sample, leaving banks in level II of the sub-sample as medium sized. Then the DID method is implemented with the same estimating specifications for the sub-samples separately to show whether the transmission effect varies with the size of the subsidiary banks.

Subsidiary Characteristics

This section first explores the heterogeneity in the subsidiary banks' characteristics. Table 2.4 presents results from the DID regressions. Six types of subsidiary bank features are tested: size, deposit, profitability, capital, liquidity and interest margin. The interaction between bank's exposure and *Post* dummy variable is the key variable of interest in these regressions.

The test on bank size shows that smaller banks are more vulnerable to the external liquidity shock if the subsidiary bank is highly exposed, since the estimated coefficient on the interaction term is only significant for banks in level I sub-sample. This could be due to the fact that smaller banks do not have access to various alternative funding sources, and hence would be more reliant on the funding from their parent bank. As a result, a liquidity shock received by the parent bank in the home country could be directly transmitted to smaller subsidiary banks. Larger subsidiary banks (banks with more assets) have easier access to alternative liquidity support (Holmstrom and Tirole, 1997).

The influence of a bank's deposit funding on the transmission effect is then examined in this section. Previous empirical work by Ivashina and Scharfstein (2010) suggests that a bank's lending activity would be more resilient during the global financial crisis if the banks had better access to deposit financing and less reliant on other forms of short-term debt. Thus it is expected that the transmission effect would be alleviated if the subsidiary banks relies more on deposit funding. However, weak evidence is found for this argument. As the table shows, the interaction term is only significant for banks in level II sub-sample, but not significant for level I or level III banks, though the coefficients are all estimated to be negative. This suggests that there is no clear trend that banks with more deposit funding would be more resilient to external liquidity shocks.

Table 2.4: Heterogeneity in Subsidiary's Characteristics

Dependent Variable:	Level I		Level II		Level III	
Loan Growth	(1)	(2)	(3)	(4)	(5)	(6)
Size						
Exposure*Post	-9.618*	-12.343*	-2.558	-2.142	-0.485	-0.331
	(5.029)	(6.421)	(2.169)	(2.650)	(1.191)	(1.848)
Observations	768	484	943	574	921	505
No. of Banks	176	125	179	127	171	104
R^2	0.132	0.235	0.162	0.217	0.241	0.246
Deposit						
Exposure*Post	-2.090	-0.681	-8.755***	-7.386*	-3.043	-1.837
	(2.100)	(5.386)	(2.918)	(3.869)	(2.475)	(2.718)
Observations	768	484	943	574	921	505
No. of Banks	174	109	173	115	173	130
R^2	0.256	0.361	0.158	0.226	0.058	0.150
Profitability						
Exposure*Post	-10.158**	-7.825	-3.774*	-4.735	-0.086	-1.570
	(4.607)	(4.917)	(2.059)	(3.244)	(1.620)	(3.011)
Observations	909	532	912	516	808	532
No. of Banks	183	126	175	116	167	112
R^2	0.112	0.155	0.146	0.205	0.240	0.215
Capital						
Exposure*Post	-0.257	0.817	-6.259*	-2.157	-4.839**	-11.265**
	(1.730)	(2.892)	(3.317)	(2.205)	(2.271)	(5.233)
Observations	876	502	924	547	832	514
No. of Banks	168	109	179	122	179	125
R^2	0.126	0.186	0.090	0.259	0.168	0.244
Liquidity						
Exposure*Post	0.900	-0.473	-4.628**	-8.435**	-6.634	-4.824
	(1.279)	(2.156)	(2.277)	(4.146)	(4.499)	(4.426)
Observations	873	520	930	591	829	452
No. of Banks	169	111	181	130	176	115
R^2	0.266	0.305	0.151	0.198	0.115	0.208
Interest Margin						
Exposure*Post	-7.797	-13.763***	-1.419	-0.018	-3.399	-7.945**
	(4.724)	(5.210)	(1.744)	(2.645)	(2.160)	(3.701)
Observations	789	377	917	594	836	557
No. of Banks	159	91	176	131	174	126
R^2	0.097	0.237	0.130	0.221	0.240	0.322
Subsidiary Controls	Yes	Yes	Yes	Yes	Yes	Yes
Parent Controls		Yes		Yes		Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents test results for heterogeneity in subsidiary bank's characteristics. Refer to Table 2.3 for full specifications. It shows that smaller bank is more vulnerable to the external liquidity shock if the subsidiary bank is highly exposed; that higher profitability would alleviate the external liquidity shock that transmitted from foreign parent banks to domestic subsidiaries; that bank with more capital would be more cautious on expanding their credit during the crisis period; that there is trend that banks with more liquid assets would reduce their lending growth more during the crisis; and that there is no clear evidence suggesting that bank's interest margin would affect subsidiary banks lending activities during the crisis period. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

In terms of bank's profitability, panel three shows that the interaction term is negative and significant if the bank has a lower ROA (level I), while it is not significant for level III banks where banks' ROA are relatively higher. Though the interaction term is also marginally significant for level II banks, there is still evidence that higher profitability would alleviate the external liquidity shock that transmitted from foreign parent banks to domestic subsidiaries.

Bank capital and liquidity are tested as a measurement for a bank's risk aversion that could have a negative effect on a bank's loan growth performance; or as a indicator for a bank's capital or liquidity constraints to expand their loan business thus could also be positively related with a bank's lending activity. De Haas and Van Lelyveld (2010) show that subsidiary banks' capital and liquidity conditions are negatively related with their lending growth, suggesting that subsidiary banks with higher capital ratios and more liquid assets would be more risk-averse thus tend to have a lower lending growth rate. Moreover, Black and Strahan (2002) suggest that less capitalised subsidiary banks are more likely to expand credit quickly due to moral hazard. These tests would show the effect of bank capital and liquid assets on a bank's lending growth when their parent bank is suffering from a liquidity crisis.

As the table shows, the interaction term is only significant for the level III sample where banks are better capitalised, while for less capitalised banks in level I the effect is estimated as small and insignificant. This implies that a bank with more capital would be more cautious on expanding their credit during the crisis period. In terms of a bank's liquidity condition, the effect is similar with bank capital. It shows that the interaction term is only significant for level II banks with a medium level of liquid assets, while it is not significant for banks in levels I and III. However, if we compare the estimated coefficient for level I and level III banks, there is a very clear trend that banks with more liquid assets would reduce their lending growth more during the crisis. These findings show that a liquidity crisis in a home country could intensify a subsidiary bank's moral hazard problem.

It also tests the influence of a bank's interest margin, which reflects a bank's capability in their core business. However, there is no clear evidence suggesting that these factors would affect subsidiary banks lending activities during the crisis period. Thus the transmission effect of ownership linkages is not likely to be affected by this characteristic of the subsidiary bank.

Parent Characteristics

This section repeats the analysis above by considering the parent banks' characteristics. The liquidity shock in home country is transmitted from parent banks to subsidiary banks located in the host countries thus it is reasonable to test whether parent banks' characteristics would affect the transmission effect, as the internal capital market hypothesis suggests. It tests four types of parent banks' characteristics: profitability, capital, liquidity and interest margin. Table 2.5 presents the results for the heterogeneity tests.

The test for parent banks' profitability shows that the interaction term is only significant in the level III sample where the parent banks have a better profitability. This suggests that if the ROA of the parent bank is higher then its foreign subsidiary, the bank tends to have a lower lending growth during crisis period. A higher profit of a bank may due to higher risks which may be adversely affected during the liquidity crisis. As a result, the bank's foreign subsidiaries may also be affected as they may highly rely on funding from their internal capital market.

It then explores the effect of a parent bank's capital and liquidity. The results in Table 2.5 show that if the parent bank is better capitalised then the liquidity shock would be more likely to transmit to its foreign subsidiary banks, since the interaction term is only significant for the sample of level III. The parent bank's liquidity condition is also negatively related to the subsidiary bank's lending growth during the crisis period. On one hand, this could be due to the fact that better capitalised banks and banks with more liquid assets are more risk-averse, thus these banks tend to cut funding support towards their foreign subsidiary banks during the crisis period. On the other hand, the moral hazard problem is amplified due to the liquidity crisis, thus less capitalised banks and banks with less liquid assets tend to take more risk to expand their credit by supporting foreign subsidiary banks.

Finally, this section tests whether the transmission effect could be affected by the capability of parent banks in the core business, which is indicated by the bank's interest margin. The interest margin test shows that the interaction term is only significant for the level I sample where the parent bank has a lower interest margin. This suggests that subsidiary banks' lending activity would be significantly affected during the crisis period if their parent bank has a low interest margin, while the negative effect is not significant for subsidiary banks with a parent bank that has higher interest margin. The results from the test imply that if the parent bank has a better performance in its core business, it would be able to keep supporting their foreign subsidiary banks during the crisis period thus the subsidiary banks' lending growth rate would not be significantly affected. Conversely, if the core business performance of the parent bank is inferior, then a liquidity shock hitting the parent bank would be transmitted to its foreign subsidiary banks.

Overall, the analysis on the heterogeneity in a parent bank's characteristics provide strong evidence for the internal capital market hypothesis. It shows that a parent bank's balance sheet structures and business capability have significant effect on the subsidiary bank's lending activity during the crisis. It is noticeable that the transmission effect is not affected by the subsidiary bank's own interest margin and weakness indicator, but can be significantly affected by parent bank's interest

Table 2.5: Heterogeneity in Parent's Characteristics

Dependent Variable:	Level I		Level II		Level III	
Loan Growth	(1)	(2)	(3)	(4)	(5)	(6)
Profitability						
Exposure*Post	-0.440	-9.760	-5.065	-4.583	-11.671**	-10.111**
	(1.548)	(9.740)	(3.187)	(2.786)	(5.267)	(4.887)
Observations	642	468	634	605	542	483
Number of Banks	135	117	134	132	121	112
R^2	0.098	0.170	0.292	0.308	0.149	0.176
Capital						
Exposure*Post	-1.528	0.974	-3.420	-6.143	-22.717***	-24.039***
	(2.773)	(2.880)	(2.257)	(3.961)	(7.455)	(9.070)
Observations	619	600	682	642	519	314
Number of Banks	137	134	145	142	109	85
R^2	0.163	0.155	0.215	0.258	0.195	0.336
Liquidity						
Exposure*Post	-0.040	-1.562	-4.161	-5.868	-4.267*	-6.917*
	(1.510)	(1.738)	(3.892)	(6.216)	(2.506)	(3.714)
Observations	573	433	608	569	584	551
Number of Banks	120	109	135	131	124	120
R^2	0.202	0.224	0.167	0.197	0.217	0.284
Interest Margin						
Exposure*Post	-4.766*	-11.053***	0.092	-4.812	6.325	1.783
	(2.870)	(3.988)	(2.402)	(4.554)	(7.766)	(3.542)
Observations	590	533	559	539	559	483
Number of Banks	126	120	118	117	125	123
R^2	0.179	0.250	0.118	0.168	0.252	0.283
Subsidiary Controls	Yes	Yes	Yes	Yes	Yes	Yes
Parent Controls		Yes		Yes		Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the test results for the heterogeneity in parent bank's characteristics. Year fixed effect and bank level fixed effect are controlled in each regression. Refer to Table 2.3 for full specifications. The test for parent bank's profitability suggests that if the ROA of parent bank is higher then its foreign subsidiary banks tend to have a lower lending growth during crisis period. Capital test shows that if the parent bank is better capitalised then the liquidity shock would be more likely to transmit to its foreign subsidiary banks. Parent bank's liquidity condition is also negatively related with subsidiary bank's lending growth during the crisis period. The interest margin test suggests that subsidiary banks' lending activity would be significantly affected during the crisis period if their parent bank have a low interest margin, while the negative effect is not significant for subsidiary banks with a parent bank that has higher interest margin. Overall, the analysis on the heterogeneity in parent bank's characteristics provide evidence for internal capital market hypothesis. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

margin and weakness, which clearly identifies that the liquidity crisis is transmitted through the internal capital market operating within a bank ownership network.

2.6.3 Subsidiary Location: West vs. East

In this section, it separates the sample according to the subsidiary bank's location to explore the difference between the subsidiaries banks located in Western European countries and those in Eastern European countries. By doing this, it examines whether the strength of the crisis transmission is contingent on the operating country of the subsidiary bank. In particular, are foreign banks in developing economies less resilient to an external liquidity shock than those foreign banks in developed economies?

As Table 2.6 shows, the estimates on the interaction term are statistically significant without parent bank controls, and the size of the negative effect is similar for subsidiary banks located in both Western and Eastern Europe. However, once it controls for parent characteristics in Columns (3) and (6), a relatively greater negative effect is estimated for Eastern European banks while the interaction term is not statistically significant for banks located in Western European countries.

This result suggests that banks located in developing countries (Eastern Europe) are more fragile when facing an external shock, compared with banks located in developed countries (Western Europe). One possible explanation is that subsidiary banks operating in developing countries are more dependent on their parent banks' liquidity support, as the financial sector is usually less developed in developing countries. For banks operating in a developed financial system, they would have easier access to alternative funding even if their parent banks or the banking group as a whole are suffering from a liquidity shock. One policy implication can be drawn here. Regulatory authorities in developing countries might wish to target liquidity regulation specifically at foreign subsidiary banks operating in their domestic banking sector. This could be justified if, as suspected, a higher dependency on parent bank funding harms the stability of the domestic banking system should an external

Table 2.6: Subsidiary Location: West vs East

Dependent Variable:	West European Banks			East European Banks		
Loan Growth	(1)	(2)	(3)	(4)	(5)	(6)
Exposure	5.732**	4.24	5.284	5.258*	1.889	9.576
	-2.883	-2.853	-4.228	-2.883	-3.481	-9.101
Post	-7.264**	-8.596**	-10.393	-22.535***	-7.742	-0.751
	-2.898	-4.323	-6.324	-5.878	-11.339	-14.118
Exposure*Post	**-4.569****	**-4.184***	**-3.023**	**-5.966*****	**-4.465****	**-10.210*****
	-2.298	**-2.301**	**-2.29**	**-1.885**	**-2.087**	**-3.740**
Subsidiary Controls		Yes	Yes		Yes	Yes
Parent Controls			Yes			Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,913	1,764	932	1,088	972	684
No. of Banks	393	367	224	245	223	169
R^2	0.03	0.067	0.124	0.057	0.213	0.252

Notes: This table shows the results for bank heterogeneity in terms of the bank's location. Refer to Table 2.3 for full specifications. The estimates on the interaction term are consistently significant without parent bank controls, and the size of the negative effect are similar for subsidiary banks located in both Western and Eastern Europe. However, once we control for parent characteristics in Column (3) and (6), a relatively greater negative effect is estimated for Eastern European banks while the interaction term is not statistically significant for banks located in Western European countries. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

liquidity shock occur.

2.6.4 Parent Location: Scenario 2 vs. Scenario 3

This section explores the heterogeneity in terms of parent banks' location. The main sample is divided into three sub-samples according to the three possible scenarios for the subsidiary banks. As mentioned in Section 2.3, there are three possible scenarios of the bank ownership network in the empirical setting of the analysis. Scenario 1 is the case where both the parent and subsidiary banks are located in non-GIIPS countries, thus they have no exposure to the crisis. In scenario 2, certain subsidiary banks from a banking group are located in GIIPS countries, thus their peer subsidiary banks located in non-GIIPS countries are indirectly exposed to the crisis due to the ownership linkages. Scenario 3 is where the parent bank of a banking group is located in the GIIPS countries, thus subsidiary banks in this banking group are highly exposed to the crisis, though they are located in Non-GIIPS countries.

The main sample is then separated in to two sub-samples according to the subsidiary banks' scenario. Notice that subsidiary banks in Scenario 1 are always included in the sub-sample as they are the control group in the DID regressions. Results are presented in Table 2.7. It shows that the negative and significant result is mainly driven by subsidiary bank in Scenario 3, as the estimates for Scenario 2 banks are consistently insignificant. This implies that subsidiary banks located in non-GIIPS countries that are indirectly exposed to the crisis were not significantly affected by the external liquidity shock, suggesting that the parent bank could act as a buffer which could isolate external shocks and stop the crisis transmission.

Table 2.7: Parent Location: Scenario 2 vs Scenario 3

Dependent Variable:	Scenario 2			Scenario 3		
Loan Growth	(1)	(2)	(3)	(4)	(5)	(6)
Exposure	0.593	0.161	-3.37	5.963***	3.341	17.260**
	-2.379	-3.013	-8.333	-2.195	-2.656	-7.04
Post	-12.530***	-6.692	-5.18	-14.105***	-10.282**	-8.674
	-2.87	-4.519	-7.597	-2.959	-4.755	-7.665
Exposure*Post	**-0.891**	**-1.12**	**1.063**	**-5.541*** **	**-4.011** **	**-8.886*** **
	-1.956	**-2.321**	**-4.582**	**-1.606**	**-1.853**	**-2.935**
Subsidiary Controls		Yes	Yes		Yes	Yes
Parent Controls			Yes			Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,655	2,403	1,336	2,579	2,342	1,256
No. of Banks	566	523	334	550	506	314
R^2	0.02	0.11	0.154	0.031	0.116	0.193

Notes: This table presents results for the Scenario test. Refer to Table 2.3 for full specifications. In scenario 2 the parent bank of a banking group is located in non-GIIPS countries, and subsidiary banks in non-GIIPS countries are indirectly exposed to the crisis; while in scenario 3 the parent bank is located in GIIPS countries thus the subsidiary banks are directly exposed to the crisis. It shows that the negative and significant result is mainly driven by subsidiary bank in Scenario 3, as the estimates for Scenario 2 banks are consistently insignificant. This implies that subsidiary banks located in non-GIIPS countries that are indirectly exposed to the crisis were not significantly affected by the external liquidity shock, as the parent bank could act as a buffer which could isolate external shocks and stop the crisis transmission. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

This analysis also presents an implication for policy makers. The performance of the foreign banks in domestic banking system are increasingly important, particularly in developing economies. Therefore, as argued above, it could be necessary for the regulatory authorities to monitor a foreign bank's parent bank and the economic and financial situation in its home country. In addition, the analysis in this section suggests that it is not so necessary to supervise the parent bank's operations in other countries, apart from its home country, as a liquidity shock received by a subsidiary bank in other countries would be isolated by the parent bank. Hence the shock would be less likely to affect the domestic banking system.

2.6.5 Network Distance to the Crisis: Level 1 vs. Level 2+ Subsidiaries

As the bank ownership network is constructed based on the banks' direct ownership linkages, it allows us to observe the position of a single subsidiary bank in the network hierarchy. Given this feature of the data, the analysis is able to explore the heterogeneity in the banks' 'network distance' to the crisis. In other words, it tests how far the liquidity crisis can be transmitted through the bank ownership network.

A Level 1 connection is defined as the connection between the parent bank and its immediate subsidiary bank, while a Level 2 connection is the connection through which the parent bank owns the subsidiary bank's subsidiaries. In this case, the network distance between Level 2+ banks and the parent bank is longer than Level 1 banks. As the crisis would be transmitted from the parent bank to the subsidiary banks in the sample, Level 1 bank are at the front line of the ownership network facing the crisis, while Level 2+ banks are farer from the crisis in the network.

The regression results in Table 2.8 show that the estimated coefficients on the DID term are consistently statistically significant for Level 1 banks across different

Table 2.8: Network Distance to the Crisis: Level 1 vs Level 2+ Connections

Dependent Variable:	Level 1 Connection			Level 2+ Connection		
Loan Growth	(1)	(2)	(3)	(4)	(5)	(6)
Exposure	8.876***	4.652	11.290**	5.214	0.275	7.556
	-3.287	-5.087	-4.841	-3.594	-2.828	-10.996
Post	-13.872***	-8.222*	-5.526	-7.883	-10.38	-10.042
	-3.018	-4.372	-6.825	-7.018	-11.615	-24.2
Exposure*Post	**-5.850***	**-3.872***	**-5.583**	**-6.707***	**-3.684**	**-16.874***
	-1.649	**-2.237**	**-2.421**	**-3.524**	**-2.826**	**-8.892**
Subsidiary Controls		Yes	Yes		Yes	Yes
Parent Controls			Yes			Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,285	2,091	1,286	716	645	330
No. of Banks	566	523	334	550	506	314
R^2	0.032	0.162	0.215	0.039	0.109	0.267

Notes: This table shows regression results for the heterogeneity test in banks' network distance to the crisis. Refer to Table 2.3 for full specifications. Level 1 connection is the connection between the parent bank and its immediate subsidiary bank, while Level 2 connection is the connection through which the parent bank owns the subsidiary bank's subsidiaries. In this case, the network distance between Level 2+ banks and the parent bank is longer than Level 1 banks. As the crisis would be transmitted from the parent bank to the subsidiary banks in the sample, Level 1 bank are at the front line of the ownership network facing the crisis, while Level 2+ banks are farer from the crisis in the network. The estimated coefficients on the interaction term are consistently significant for Level 1 banks across different models while for Level 2 banks the coefficients are estimated less significant. It implies that the bank ownership network could act as a liquidity crisis transmission while its power would be limited to the Level 1 connections. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

models while for Level 2 banks the coefficients are not consistently significant at conventional levels. This implies that the bank ownership network could act as a liquidity crisis transmission while its power would be limited to the Level 1 connections, as the negative effect on Level 2+ banks is weaker. This result implies that subsidiary banks can also act as a buffer thus alleviating the liquidity shock within the network, and stop the crisis being transmitted further. This is consistent with the implication from the previous analysis on banks in different scenarios. Both analyses could help policy makers to consider the extent to which the foreign banks and their parent banks need to be supervised and regulated.

2.7 Robustness Checks

2.7.1 Dynamic Difference-in-Differences

This section estimates the dynamic DID method to examine the main hypothesis; results are presented in Table 2.9. The estimated coefficient on *Exposure* is still positive and statistically significant; this is consistent with the estimates from the conventional DID regressions. The key terms in these regressions are the interactions between *Exposure* and year dummy variables, rather than the *Post* dummy variables in the conventional DID method. The interaction with the dummy variable for the year of 2008 is the omitted base year. As Table 2.9 shows, the estimated coefficients on the interactions between *Exposure* and dummy for the year 2009 are negative but not statistically significant, which suggests that the difference in lending growth between highly exposed banks and less exposed banks in the year of 2009 are not statistically different from the year of 2008. This implies that there is a common trend between bank's lending activity over the pre-crisis period, which satisfies one of the key assumptions of the DID approach. Then, the interaction terms become significant starting from the year of 2010 which is the first year of the crisis. As column (1) shows, the estimates on interaction terms for each year in the crisis period are negative and significant and the size of the effect is considerable, suggesting that bank's exposure has a long-term negative effect on bank's lending activity. However, once subsidiary bank's characteristics are included as control variables in column (2), both the significance and size of the interaction estimates decrease, especially for the years of 2012 and 2013. Moreover, as column (3) results show, once we add parent bank's characteristics in to the regression, the significance drops further, and the negative number for the year of 2013 is no longer significant. Overall this implies that bank's exposure has a pronounced effect during the crisis period (2010-2012), but it reverts back to the mean in 2013.

Table 2.9: Robustness Checks: Dynamic Difference-in-Differences

Dependent variable:	Dynamic DID		
Loan Growth	(1)	(2)	(3)
Exposure	6.873***	4.611*	8.428
	(-2.558	(-2.682)	(-5.401)
Exposure * 2009	-2.977	-3.391	-3.117
	(-2.319	(-2.455)	(-2.387)
Exposure * 2010	-5.787**	-4.989**	-6.512**
	(-2.294	(-2.304)	(-3.027)
Exposure * 2011	-7.635***	-6.350***	-7.922**
	(-2.167	(-2.180)	(-3.129)
Exposure * 2012	-6.117***	-4.820**	-6.592*
	(-2.145	(-2.200)	(-3.581)
Exposure * 2013	-6.663***	-5.563**	-5.714
	(-2.027	(-2.158)	(-3.791)
Subsidiary Controls		Yes	Yes
Parent Controls			Yes
Year FE	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Observations	3,001	2,736	1,616
No. of Banks	638	590	393
R^2	0.032	0.11	0.16

Notes: This table shows the robustness check for the baseline result with a dynamic DID setting. Refer to Table 2.3 for full specifications. Year effect and bank level fixed effect are controlled in each regression. We do not include any control variables in the first regression while the second regression includes controls for subsidiary's characteristics and then in the third regression we further include controls for parent's characteristics. The number of observations decreases as we include more control variables into the model due to data availability. The interactions between *Exposure* and year dummy variables are the key term in the dynamic DID regressions. Overall, the estimates from the dynamic DID approach are consistent with the findings from the conventional DID method that the liquidity crisis in GIIPS countries were transmitted to other European countries though bank's cross-border ownership linkages. What is more, the dynamic DID regressions show that the transmission effect is most effective in 2011 when the GIIPS crisis reach the peak, and it dies out in the year of 2013 as the crisis is mitigated in most GIIPS countries. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Another implication from the dynamic DID analysis is that the magnitude of the negative effect of bank's exposure reaches its highest level in 2011, when the GIIPS sovereign debt crisis also peaked, as suggested by Figure 2. This trend is consistently predicted by all three models. Looking at column (3), for instance, banks with 1 percent higher exposure would reduce their lending growth rate by 6.51 percentage points in the year of 2010, while in 2011 these banks would reduce lending growth rate by 7.9 percentage points, compared with the lending growth rate in the base year, 2008. In 2012, the negative effect of exposure on loan growth rate reduces to 6.59 percentage points, and it is only significant at 10 percent level. This effect drops further in the year of 2013, and becomes no longer significant.

2.7.2 Dynamic Ownership Network

The baseline results of the analysis are estimated based on a static bank ownership network, which is constructed with bank ownership data in December 2010. Throughout the analysis, it assumes that the ownership network did not change over the sample period. However, the networks may have changed over the crisis period. The reason why the analysis initially focused on a static network is that the direct ownership data in Bankscope is not consistently recorded for bank in each year. Some ownership linkages are not recorded in a specific year while they appear in later periods. In this case, a dynamic network may no be accurate due to the noises created by missing ownership data in the database.

In this section, the DID analysis is conducted based on a dynamic ownership network as a robustness check for the baseline result. The dynamic ownership network is constructed year by year using the time varying ownership data. The regression results are presented in Table 2.10. It reveals that the estimated coefficient on the key terms are qualitatively the same as the baseline results. Overall, the robustness checks confirm the baseline results that the liquidity crisis in GIIPS countries were transmitted to other European countries through bank's cross-border ownership linkages.

Table 2.10: Robustness Check: Dynamic Ownership Network

Dependent Variable:	Conventional DID		
Loan Growth	(1)	(2)	(3)
Exposure	2.461	0.84	1.94
	(-1.736)	(-1.878)	(-2.716)
Post	-11.940***	-9.876**	-12.476**
	(-3.066)	(-4.073)	(-4.905)
Exposure*Post	**-4.617*** **	**-3.385** **	**-3.829** **
	(-1.491)	**(-1.564)**	**(-1.725)**
Subsidiary Controls		Yes	Yes
Parent Controls			Yes
Year FE	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Observations	2,753	2,519	1,899
No. of Banks	575	531	462
R^2	0.029	0.08	0.11

Notes: This table shows the robustness check for the baseline result with a dynamic ownership network, which is constructed year by year using the time varying ownership data. Refer to Table 2.3 for full specifications. The estimated coefficient on the key terms are qualitatively the same with the baseline results. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

2.7.3 Different Crisis Timing

Following the literature (Popov and Van Horen, 2015; De Marco, 2013), the previous analysis uses the year of 2010 as a cut-off between the pre- and post-period of the debt crisis in the GIIPS countries. A potential concern with this setting is that it may be appropriate for the crises in Greece, Spain, and Ireland but not in Portugal or Italy, as the sovereign shocks from these two countries actually were materialised in 2011. Thus, it maybe preferable to use the year during which a crisis starts in a country as this country's Year 0 and then use years -2, -1, +1, and +2, etc. to label the years as pre- and post-period, to analyse a banking network's exposure to a country in relation to the crisis in that country. This procedure may produce stronger results.

This section examines whether the baseline results could be affected by a different

Table 2.11: Robustness Check: Different Crisis Timing

Dependent Variable:	Original Results			New Crisis Timing		
Loan Growth	(1)	(2)	(3)	(4)	(5)	(6)
Exposure	5.325**	3.083	7.108	5.190***	3.016	6.39
	-2.1	-2.257	-4.794	-1.988	-2.164	-4.794
Post	-12.918***	-7.701*	-5.017	16.427*	11.945	30.122**
	-2.767	-4.323	-6.73	-9.702	-10.573	-11.721
Post * Exposure	**-5.189*** **	**-3.920** **	**-5.756** **	**-5.112*** **	**-3.866** **	**-5.326** **
	-1.476	**-1.59**	**-2.354**	**-1.409**	**-1.526**	**-2.325**
Subsidiary Controls		Yes	Yes		Yes	Yes
Parent Controls			Yes			Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,001	2,736	1,616	3,001	2,736	1,616
No. of Banks	638	590	393	638	590	393
R^2	0.03	0.108	0.158	0.049	0.141	0.196

Notes: This table shows results from the robustness check for the baseline result with a different crisis timing. Refer to Table 2.3 for full specifications. It defines the crisis dummy Post equal to 1 for Greece, Ireland and Spain from 2010 onward; otherwise 0. Meanwhile it defines Post equal to 1 for Italy and Portugal from 2011 onward; otherwise 0. As it shows, the regression results with the new crisis timing turn out to be consistent with the baseline results, and the magnitude of the effect is estimated to be very close in each model. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

timing of the crisis period. First, it defines the crisis dummy Post equal to 1 for Greece, Ireland and Spain from 2010 onward; otherwise 0. Meanwhile it defines Post equal to 1 for Italy and Portugal from 2011 onward; otherwise 0. The results are presented in Table 2.11, along with the original results. As it shows, the regression results with the new crisis timing turn out to be consistent with the baseline results, and the magnitude of the effect is estimated to be very close in each model.

In addition, the new crisis timing is also introduced into the dynamic DID regressions. The crisis dummies are created for each GIIPS country in each year. For example, the dummy variable Crisis + 1 is defined to be equal to 1 for Greece, Ireland and Spain in 2010; otherwise 0. But the same dummy variable is defined to be equal to 1 for Italy and Portugal in 2011; otherwise 0. The results from the dynamic DID regressions with this new crisis timing are presented in Table 2.12, along with

Table 2.12: Dynamic DID with different crisis timing

Dependent Variable:	Original Results			New Crisis Timing		
Loan Growth	(1)	(2)	(3)	(4)	(5)	(6)
Exposure	6.873***	4.611*	8.428	0.869	-0.639	4.88
	-2.558	-2.682	-5.401	-1.304	-1.303	-4.519
Exposure * 2009	-2.977	-3.391	-3.117			
	-2.319	-2.455	-2.387			
Exposure * 2010	-5.787**	-4.989**	-6.512**			
	-2.294	-2.304	-3.027			
Exposure * 2011	-7.635***	-6.350***	-7.922**			
	-2.167	-2.18	-3.129			
Exposure * 2012	-6.117***	-4.820**	-6.592*			
	-2.145	-2.2	-3.581			
Exposure * 2013	-6.663***	-5.563**	-5.714			
	-2.027	-2.158	-3.791			
Exposure * Crisis - 1				-1.201	-2.556	-1.187
				-1.929	-1.879	-2.195
Exposure * Crisis + 1				-3.259**	-3.422**	-4.006*
				-1.531	-1.432	-2.391
Exposure * Crisis + 2				-2.932***	-2.386**	-5.885***
				-1.01	-0.971	-1.928
Exposure * Crisis + 3				-1.952*	-1.127	-3.692
				-1.014	-0.973	-2.8
Subsidiary Controls		Yes	Yes		Yes	Yes
Parent Controls			Yes			Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
No. Observations	3,001	2,736	1,616	3,001	2,736	1,616
No. of Banks	638	590	393	638	590	393
R^2	0.032	0.11	0.16	0.027	0.107	0.159

Notes: This table shows results from the robustness check for the dynamic DID regressions with a different crisis timing. Refer to Table 2.3 for full specifications. The crisis dummies are created for each GIIPS country in each year. For example, the dummy variable Crisis + 1 is defined to be equal to 1 for Greece, Ireland and Spain in 2010; otherwise 0. But the same dummy variable is defined to be equal to 1 for Italy and Portugal in 2011; otherwise 0. As it shows, the estimations from the new regressions are again consistent with the original results. Furthermore, the common trend assumption holds in both settings. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

the original results. The estimations from the new regressions are again consistent with the original results. Furthermore, the common trend assumption holds in both settings.

2.7.4 Definition of the Subsidiary Bank

Another concern related to the empirical setting is related to the definition of a subsidiary bank in a bank ownership network. In the previous analysis, an effective ownership linkage between parent and subsidiary banks is defined by a control stake where the parent bank holds 50% or more of the subsidiary bank's total equity. However, the ownership level of subsidiaries may create some noise in the results. For example, 50% ownership may not be as strong as 90% ownership in affecting the contagion. If a bank is only 50% owned by the parent may have more room to resist influence from the parent than a bank that is 90% owned by the parent. This section explores the heterogeneity among subsidiary banks with different levels of the ownership linkages.

Table 2.13: Distribution of Different Level of Ownership Linkages

Ownership Level	No. of Banks	No. of Obs.	Percent	Cum.
50% 59%	66	340	11.28	11.3
60% 69%	26	131	4.34	15.6
70% 79%	40	210	6.97	22.6
80% 89%	26	123	4.08	26.7
90% 100%	481	2,211	73.33	100
Total	639	3,015	100	-

Notes: This table shows the number of subsidiary banks with different level of the ownership linkages in the sample. As it shows, over 70 percent of ownership linkages in the sample are more than 90% owned. In other words, most of the entities are close to wholly owned subsidiaries rather than joint ventures.

As Table 2.13 shows, over 70 percent of ownership linkages in the sample are more than 90% owned. In other words, most of the entities are close to wholly owned subsidiaries rather than joint ventures. Based on this fact, the main sample is split into two sub-samples using 90% as the cut-off. The baseline regression is then performed with the two sub-samples separately, and the results are presented in Table 2.14. As it shows, the DID term for the group with stronger ownership ties is consistent with the baseline results and statistically significant. For the weaker ownership links, the estimated coefficients are similar but the standard errors are larger given the smaller number of observations in the group. So overall, there is not much evidence of heterogeneity in the effect size.

Table 2.14: Subsidiary Banks with Different Levels of Ownership Linkages

Dependent Variable:	50% - 90%			90% - 100%		
Loan Growth	(1)	(2)	(3)	(4)	(5)	(6)
Exposure	20.414*	21.9	29.460*	8.726**	10.020**	10.820**
	-12.262	-17.939	-16.848	-3.439	-4.273	-5.056
Post	-10.400**	-16.189**	-5.205	-14.050***	-5.469	-6.518
	-4.974	-6.219	-8.89	-3.13	-4.831	-7.501
Post * Exposure	**-8.837****	**-9.835**	**-6.323**	**-5.712*****	**-5.633*****	**-5.529****
	-4.217	**-6.056**	**-4.982**	**-1.749**	**-1.963**	**-2.291**
Subsidiary Controls		Yes	Yes		Yes	Yes
Parent Controls			Yes			Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	804	758	442	2,211	1,992	1,268
No. of Banks	158	152	104	481	439	312
R^2	0.054	0.088	0.103	0.031	0.138	0.167

Notes: This table shows results from the test for heterogeneity among bank with different levels of ownership linkages. Refer to Table 2.3 for full specification. As it shows, the DID term for the group with stronger ownership ties is consistent with the baseline results and statistically significant. For the weaker ownership links, the estimated coefficients are similar but the standard errors are larger given the smaller number of observations in the group. Overall, there is no clear evidence of heterogeneity in the effect size. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

2.8 Conclusion

Over the past two decades, the world's economies are increasingly interconnected through bank ownership ties. There has been a substantial increase in foreign bank ownership in the domestic banking system. As such, it is important to understand the possible consequences of the interconnectedness of the global banking system. It has been argued that the presence of foreign banks can stimulate competition and innovation in domestic banking system thus improving the overall efficiency of the financial sector. This should have a long-term positive effect on the development of the domestic economy. However, a large proportion of foreign owned banks could expose the domestic baking system to international liquidity crises. This chapter examined whether a liquidity crisis can be transmitted internationally through a bank's cross-border ownership linkages.

The 2010 European debt crisis provided a unique opportunity to identify this transmission. The ownership network for international banks operating in the European countries was constructed, based on the ownership data provided by Bankscope. Then the exposure to the liquidity crisis in GIIPS countries was calculated for each subsidiary bank located in non-GIIPS countries, measured by the proportion of their banking groups' assets in GIIPS countries. The Difference-in-Differences method was implemented to examine the transmission effect. The results from the DID regressions show that the treatment has a negative and significant effect on a bank's lending growth rate during the crisis period, and the magnitude of the effect is large. Overall the results of this study suggest that subsidiary banks operating in non-GIIPS countries who were exposed to the liquidity crisis in GIIPS countries due to the ownership linkages tend to have a lower lending growth rate during the crisis period, compared with those who were not exposed. This, in turn, suggests that the liquidity crisis in GIIPS countries banking system was transmitted to other European countries through cross-border bank ownership linkages.

This study also presents opportunities for future work. While the current data has allowed this study to identify ownership ties, given the relatively small number of observations within GIIPS countries and incomplete information on changes in ownership over time it has been unable to test the 'support effect' of the internal capital market, where the 'support effect' is the notion that subsidiary banks suffering liquidity shock in GIIPS countries could be supported by their owners located outside of GIIPS countries.

An important caveat to the findings is that it cannot fully capture the banks' exposure to government bonds. While one can control for the bank-specific time-invariant levels of exposure through a bank-fixed effect, it is not possible with the current data to control for the time-varying exposure to GIIPS debts.

This analysis has implications for policy in terms of the regulation of international banks. First, as a liquidity shock can be transmitted through cross-border bank ownership linkages, regulatory authorities across countries might to think carefully about the activities of international banks and whether any of these should be ring fenced. Specific policies targeted at international banks so as to isolate foreign liquidity shocks could help support the stability of a domestic banking system. While such regulation may come at an operational cost for the banks involved, this has to be balanced against the need for a stable financial system. Second, this chapter provides empirical evidence for operation of the internal capital market within banking groups in which international banks allocate their banking assets in order to maximise the profits. Regulators across countries would do better to coordinate their activities and agree policy on an international rather than domestic level. This may help alleviate the potential for contagion across an international bank's internal capital market.

Chapter 3

SOVEREIGN DISTRESS, BANK STRENGTH AND PERFORMANCE:

Evidence from the Euro-zone Sovereign Debt Crisis

3.1 Introduction

The European sovereign debt crisis showed how banks' exposures to distressed governments could be associated with financial instability. Large sovereign exposures could lead to a 'doom loop' between the banking sector and sovereigns (Farhi and Tirole, 2016): banks with large exposures to distressed sovereigns reduce lending, causes slower economic growth, leads to greater sovereign distress. This *sovereign-bank diabolic loop* has become a first-line political matter after the recent European sovereign debt crisis. The recent global financial crisis reinforced the economic weaknesses of some countries, which increased their risk of insolvency of their governments, with sovereign yields soaring in particular until the summer of 2012. The drop in some sovereign bond prices impacted banks' balance sheets, in particular for Euro Area banks, subsequently affecting lending to the real economy (Popov and Van Horen, 2015; Acharya et al., 2016). The sovereign-bank diabolic loop was hence reinforced, with banks less able to support a stronger post-crisis recovery that could have alleviated some of the pressures to public finances.

Importantly, bank capital regulation *de facto* assumes that the credit risk associated with sovereign exposures is null: national discretions allow national authorities to choose a 0% risk weight on their own sovereign exposures, and to reciprocate if other national authorities have chosen to do the same for their own sovereigns. This is in fact the case in Europe. Some authors have suggested that this feature has amplified the cross-border sovereign risk spillovers (Kirschenmann et al., 2016), as it allowed banks to be exposed to risky sovereigns without backing these exposures with capital.

As a consequence of the sovereign debt crisis in the Euro Area, the Basel Committee on Banking Supervision (BCBS) is reviewing the regulatory framework for sovereign exposures.[1] One argument is that if banks had more capital backing these exposures, they would be more isolated from the sovereign distress and hence the effect on credit supply would be reduced. Another argument, however, is that banks, especially domestic ones, cannot possibly isolate from sovereign risk, and hence a stronger capital position would not have prevented the contagion effect.

This chapter sheds light on the main channels through which shocks to the value of sovereign bonds may affect bank lending behaviour and whether capital could alleviate the transmission mechanism. It uses the European Banking Authority (EBA) stress tests and transparency exercises, which contain granular information of banks sovereign exposures, in order to focus on the accounting definition of these exposures, since some exposures are recorded mark-to-market while others at book valuation. This allows the analysis to have a much more precise estimate of how exposed to the sovereign debt turmoil banks are. These data are matched with bank-level balance sheet information obtained from SNL, such as solvency ratios, asset size, or position in the interbank market, from 2010 to 2016.

In line with previous studies, it suggests that negative shocks to sovereign bond prices are associated to lower subsequent bank lending for banks more exposed to the shocks, but these relation is weaker for better capitalised banks (Kirschenmann et al., 2016), what is known as the 'capital channel'. Moreover, it shows that bank capital matters especially for exposures that are both mark-to-market and subject to no capital requirements, such as available for sale (AFS) exposures: this seems to be the type of exposure through which sovereign shocks are transmitted directly to bank solvency. The capital channel is less important for book-value exposures (held to maturity (HTM)) and exposures with positive capital requirements (held for trading (HFT)). It also reveals that the capital channel is particularly important for short-term exposures (rather than medium- and long-term) and domestic exposures

[1] `https://www.bis.org/bcbs/bcbs_work.htm`.

(rather than foreign). These results provide useful evidence to design a more robust regulatory capital framework for sovereign exposures. If the goal of the reforms is to better isolate banks' balance sheets from sovereign shocks, the accounting classification of the sovereign exposures should be taken into consideration.

The rest of this chapter proceeds as follows. Section 3.2 reviews current literature that is related to the sovereign-bank nexus and the impact of the application of fair value accounting. Section 3.3 describes the data that would be analysed using the econometric method presented in section 3.4. Section 3.5 presents the regression results and offers a discussion before section 3.6 concludes this essay.

3.2 Literature Review

This research connects to a growing literature on the topic of bank's sovereign exposures, where a great effort has been made since the Euro Area sovereign debt crisis. One strand of literature focuses on bank's motivation for taking on sovereign exposures during the crisis. Two types of motivations are proposed: moral suasion and carry trade. The moral suasion hypothesis argues that banks in distressed countries would increase their exposures to domestic sovereign debt during the crisis as the government would put pressure on banks in order to get extra funding from the banking system. Uhlig (2014)'s theoretical framework interacts banks, banking regulation, government default risk and central bank guarantees in a monetary union. The model assumes that sovereign bonds can be used by banks in repurchase agreements with the common central bank, and suggests that banking regulators in distressed countries have incentives to allow banks to hold more risky domestic bonds, in order to pass the cheaper funding from the common central bank onto the government in distress through the banking system. In effect, the default risk would be shifted from the domestic banking system to the common central bank. In other words, the distressed government would be indirectly financed by the common central bank through domestic banking system by loosening banking regulation. This model provides a theoretical foundation for the moral suasion hypothesis.

Becker and Ivashina (2014) documents the fact that domestic sovereign bond holding positions of Euro Area banks substantially increased following the global financial crisis. Using firm level data, the authors further show that bank credit supply to the private sector has been crowded out by the increase in the banks' sovereign exposure: firms are less likely to get financed through bank loans when the banking system are more exposed to domestic sovereign debt, and when the sovereign debts are risky. More interestingly, this paper shows that the distressed government exercise financial repression with respect to domestic banking system through two channels: direct government ownership and board seats, which is consistent with the moral suasion hypothesis.

Using monthly frequency data on banks' sovereign debt holdings from the ECB, Ongena et al. (2016) shows that during the Euro Area sovereign debt crisis domestic banks in distressed countries tend to increase their exposures to risky domestic sovereign debt by more than foreign banks. They also find this effect is more pronounced for those domestic banks with higher government ownership and lower initial government bond holdings. Their results suggest that this moral suasion mechanism is robust controlling for the LTRO by ECB and it is not driven by other concurrent motivations such as risk-shifting, carry-trade and so on.

De Marco and Macchiavelli (2015) also provide empirical evidence for moral suasion hypothesis. Using sovereign exposure data disclosed by EBA EU-wide stress tests and capital exercises, they argue that state-owned banks and banks with politicians as board directors tend to have a stronger home bias than other banks during the sovereign debt crisis: they tend to hold a higher fraction of domestic government bonds in their total government bond portfolio. The authors further show home bias strengthened only for state-owned banks over the crisis period, and this effect is more pronounced in crisis countries. This result is consistent with Becker and Ivashina (2014) that banks can be influenced by the distressed government through both the ownership and board seat channel.

On the other hand, the carry trade hypothesis argues that banks tend to use unsecured short-term funding from the wholesale market to finance their investment in long-term risky government bonds issued by peripheral Euro Area countries which offer higher return, without extra bank capital. By doing so, banks intend to earn the spread between the higher return from the sovereign debt investment and the return lower cost of short-term funding in an effort to gamble for resurrection. A carry trade motivation is also suggested by both theoretical models and empirical evidence. Crosignani (2015)'s theoretical model introduces a government and a banking sector for each country in a two-country and two-date setting. The model assumes that banks can lend to domestic private sector and invest in both domestic and foreign government bonds. Meanwhile governments issue debts and impose taxes on banks' income from lending to the private sector to maximise their expenditure. In the good states, the taxes collected by the government would be sufficient enough to repay their debts. However, the government cannot make the repayment in the bad states, which introduces the risk of sovereign default. Assuming limited liability for banks which gives them the risk-shifting incentive, the model predicts that less-capitalised banks tend to have a higher level of domestic sovereign debts, which is consistent with the carry trade hypothesis.

Acharya and Steffen (2015) empirically documents bank's carry trade behaviour during the European sovereign debt crisis, focusing on the publicly listed European banks that participated in the EBA stress tests and capital exercises throughout the 2010 to 2012 period. They authors show that European banks use short-term funding to finance their investment in long-term debts issued by peripheral countries. They further show that banks with a higher short-term leverage, higher risk-weighted assets and lower regulatory capital ratio would have a higher level of peripheral sovereign debt. In addition, their results suggest that this result is not driven by home bias or moral suasion as banks in non-Euro Area countries are also highly exposed to the peripheral sovereign debts.

Acharya et al. (2016) also shows that less capitalised banks and banks with more government interventions increase their exposures to the domestic sovereign debts, indicating the effect of both carry trade and moral suasion channel. In addition, using bank-firm relationship data collected from DealScan database and firm level data from Amadeus database, they identify that firms associated with GIIPS banks [2] tend to perform worse during the sovereign debt crisis period compared with those only associated with non-GIIPS banks. Furthermore, the authors show that only the carry trade channel has a negative and significant real effect on borrowing firms while moral suasion channel has no significant effect on the firms' corporate policies.

Horváth et al. (2015) shows similar results by also using the EBA sovereign exposure dataset. This paper provides empirical evidence that riskier bank in crisis countries tend to have a higher level of home bias in terms of government bond holdings, where bank risk is measured by leverage. This result is consistent with the implication of the carry trade hypothesis that less capitalised banks tend to increase their holdings in risky sovereign debts. Furthermore its results also support moral suasion hypothesis as it shows that home bias is more pronounced for government owned bank, indicating the influence of the government on those banks.

Both carry trade and moral suasion hypothesis are also suggested by Altavilla et al. (2016). They exploit the monthly government bond holding data for Euro Area banks recorded by the ECB, then show that government-owned banks, recently bailed-out banks, and less capitalised banks in crisis countries tend to increase their domestic government bond holdings during the crisis period. They also show that the increased sovereign risk significantly reduced bank lending, given banks' exposure to the sovereign debts.

Buch et al. (2016) shows evidence on carry trade hypothesis by focusing on banks located in Germany, rather than those in crisis countries. Using granular data on German banks' sovereign debt holdings provided by the Deutsche Bundesbank, they find that less capitalised banks tend to increase their sovereign exposure during the Euro Area sovereign debt crisis. They further show that the risk of a bank's sovereign

[2] That is, banks in Greece, Ireland, Italy, Portugal and Spain.

debt portfolio is positively correlated with the risk of the bank itself.

Overall, these papers provide empirical evidence supporting both the moral suasion hypothesis and the carry trade hypothesis, which explains why banks tend to hold or even increase their exposures to distress sovereigns during the sovereign debt crisis period. However, these papers do not examine how banks' exposure to the distressed sovereigns would have an effect on banks themselves given a sovereign shock.

Another strand of literature on bank sovereign exposures focuses on how a sovereign shock would have an impact on the performance of the banking system, usually measured by bank default risk and credit supply. This research question is critical as a sovereign crisis might cause a banking crisis that could possibly evolve into an overall economic recession, as was seen in several peripheral European countries during the sovereign debt crisis.

A two-way feedback model is proposed by Acharya et al. (2014) to explain the relationship between the riskiness of the government and the domestic banking system. They introduce three sectors in the model: financial sector, non-financial corporate sector and government. Aggregate output is jointly produced by both financial and corporate sector, where the financial sector is leveraged, thus insolvency is possible. In the model, government has the option to bailout the financial sector, by either increasing the tax on the corporate sector or borrowing from the financial sector. However, both types of the government's funding sources are limited. It cannot always increase tax revenue from the corporate sector due to the Laffer curve of taxation, while extra borrowing from the financial sector can be costly as the value of the existing sovereign debts held by the financial sector would be diluted, causing "collateral damage" which would further damage the financial sector. In this setting, if the optimal size of a government bailout is sufficiently large, the bailout cannot be financed by taxation thus sovereign debts dilution would become the preferable solution. This two-way feedback mechanism implies a so-called doom loop between a sovereign crisis and a banking crisis. Empirically, Acharya et al. (2014) verifies this loop by testing the correlation between the risk of sovereign and bank indicated by their CDS spread, over the 2007 to 2011 period. The result shows that the bank CDS spread would increase by 0.9% if the sovereign CDS spread increases by 10% during the post-bailout period, while there is no significant relationship between them before the bailout.

Cooper and Nikolov (2013) proposed a theoretical model interacting the government bond market with the financial market, by combining the sovereign debt fragility model developed by Calvo (1988) with the bank run model developed by Diamond and Dybvig (1983). The doom loop between sovereign and banking crisis is established given the two facts that 1) banks tend to invest in a large amount of long-term government bonds as their liquidity reserves; and 2) government provide both explicit and implicit guarantees to the banking system. Given a potential sovereign default, the banking sector would be negatively affected as it is highly exposed to the government bonds. In order avoid bank default, government would bailout those banks in trouble financed by extra borrowing, which in turn causes a further deterioration of the government bond market, thus the balance sheet of banking sector that requires a even larger bailout. This result is consistent with the prediction of the model by Acharya et al. (2014).

Leonello (2014) also theoretically confirms the diabolic loop between the sovereign and banking crisis, allowing the interaction between the sovereign debt market and the banking sector. Moreover, the model suggests that a government guarantee would reduce the probability of both a sovereign default and a banking crisis if the banking sector is highly productive or the government has a low level of public expenditure. However, given a banking system with low productivity or a government with high public expenditure, though the banking sector would benefit from the government guarantee, a sovereign default is more likely to happen with increased borrowing cost for the government. Different from the doom loop models with focus on a closed economy, Farhi and Tirole (2016) proposes a "double decker bailout" model for the feedback loop mechanism, which allows for both domestic banking system bailout by the government and sovereign debt forgiveness by foreign claimholders. Their paper provides implications for sovereign debt renationalisation and banking unions.

Using a different theoretical framework, Bocola et al. (2016) introduces the risk of sovereign default into a business cycle model with financial intermediation, based on the framework developed by Gertler et al. (2010) and Gertler and Karadi (2011). In the model, banks either lend to the firms or invest in the government bonds, using deposits collected from households along with their own funds. As banks are usually highly exposed to the sovereign debts, the model predicts that a potential sovereign default that drives down the the market value of the government bonds would have a negative effect on banks' lending to the private sector through two channels: a liquidity channel through which devaluation of the government bonds reduces the borrowing capacity of the banks; and a risk channel because the net worth of the bank would be driven down. The model is estimated by using Italian data, which shows that the sovereign debt crisis in Italy increased the borrowing cost for firms and the risk channel contributed 45 percent of the effect. Overall the sovereign crisis in Italy is estimated to have decreased aggregate output by 1.4 percent.

Gennaioli et al. (2014b) also proposed a theoretical model for the effect of a sovereign default on the private credit supply from the banking system. The model suggests that banks tend to hold government bonds as their liquidity reserve. Thus, sovereign default would deteriorate banks' balance sheet and also dry up the liquidity of the banking system, resulting in a decrease in the banking credit supply. Furthermore it shows that the adverse effect of sovereign default would be larger in countries with more developed financial institutions and in banking systems which are more exposed to the sovereign debt. Using country-level data, empirical evidence is also provided. It documents 110 sovereign default episodes in 81 countries from 1980 to 2005, based on the S&P rating data, then shows that banking systems that are highly exposed to the government bonds tend to reduce their credit supply to the private sector in a sovereign default episode. In a companion paper, Gennaioli et al. (2014a) collects bank-level information from Bankscope database. Using the same empirical setting and econometric method, it shows that banks with higher government bond holdings tend to have a lower lending growth rate given a sovereign default shock, confirming their country-level findings at a bank-level.

Also using the sovereign rating data, Adelino and Ferreira (2016) explore the causal effect of sovereign downgrades on bank lending. It argues that the rating of a bank could be negatively affected if the rating of the bank's home country is downgraded. As a result, it would induce an adverse effect on bank's borrowing cost and capacity to borrow in the wholesale funding and bond markets, given the fact that a rating is an important investment criterion for institutional investors in these markets. This in turn would have a negative effect on a bank's lending activity. Using historical sovereign downgrading data from S&P and loan-level syndicated lending data from DealScan, their empirical analysis confirms the hypothesis that sovereign downgrading event has a negative effect on bank's syndicated lending supply.

Many papers in the literature have focused on the 2010 Euro Area sovereign debt crisis. Popov and Van Horen (2015) exploits a typical difference-in-difference setting to examine the performance of the European banks that are highly exposed to the GIIPS debt over the crisis period. Banks' sovereign exposure data were collected from the disclosure of the 2011 EBA stress test which provides detailed sovereign exposure information for 90 major European banks as of December 2010. They collect syndicated lending data from Dealogic Database for 34 non-GIIPS banks that participated in the 2011 EBA stress test, and the empirical results suggest that those non-GIIPS banks that were highly exposed to GIIPS debt significantly reduce their syndicated lending after the 4th quarter of 2010. Though it argues that the transmission mechanism might be due to both capital and funding channel, their empirical analysis is quite silent on which of these channels was more important.

De Marco (2015) uses a very similar empirical setting with Popov and Van Horen (2015) to explore the causal relationship between the Euro Area sovereign debt crisis and credit supply. Banks' exposures to the sovereign crisis are also measured using the sovereign holding data provided by the 2011 EBA stress test. It confirms Popov and Van Horen (2015)'s finding that highly exposed banks tend to have a lower growth rate in syndicated lending during the crisis period. Furthermore, it empirically tests both the capital channel and funding channel, and the results suggest that only funding channel matters. However, this result is just based on an analysis of a relatively short period around the year of 2010 where banks' sovereign exposure data are provided.

Acharya et al. (2016) goes a step further to explore the real effect of the sovereign debt crisis. It collects bank-firm relationship data from DealScan and firm-level data from Amadeus, then shows that firms associated with banks that are highly exposed to the sovereign crisis tend to perform worse in terms of investment, job creation and sale growth, compared with those associated with less exposed banks. The adverse real effect on firms might also be due to the increase in the cost of corporate financing during the sovereign debt crisis, as documented by Augustin et al. (2014).

Bofondi et al. (2013) focuses on the Italian banking system to explore the causal link between sovereign risk and bank lending. They collect loan-level data for all Italian banks from the Italian Central Credit Register and construct a sample containing 670,000 bank-firm linkages from December 2010 to December 2011. They use foreign banks operating in the Italian banking system as control group, and show that domestic banks tend to have a lower lending growth rate, which suggests that credit supply has been tightened by the banks that are highly exposed to the crisis. However, this paper does not explain the transmission channel of the effect of sovereign risk on bank lending.

Korte and Steffen (2015) shows some indirect evidence of a capital channel. The paper's central hypothesis is that during the Euro Area sovereign debt crisis, sovereign risk (measured by sovereign CDS spreads) across EU countries tend to move in a similar way and the co-movement would be more pronounced when the domestic banking systems are highly exposed to foreign sovereign debts that are not funded with their bank capital. They construct an index for the EU sovereign CDS market, using the outstanding debt of each EU government as the weight, and find that the sovereign CDS spread has a stronger co-movement with the EU CDS index when the level of capital against sovereign exposures in the domestic banking system is low. They also re-estimate the tests only for non-GIIPS countries where the EU CDS index is replaced by the individual GIIPS CDS spreads and find that the co-movement is more pronounced if the banking system are more exposed to the respective GIIPS country without the support of bank capital.

In summary, this strand of literature suggests that a sovereign shock would have a negative effect on banks that are exposed to the sovereign through their government bond holdings. Two transmission channels were proposed in the this strand of literature: capital channel and funding channel. However, the empirical evidence on these two transmission channels is not clearly provided. Thus, this chapter aims to fill this gap in the literature and provide evidence on how exactly sovereign shocks can negatively affect banks' lending activities.

This chapter is also related to studies on the effect of application of fair value accounting on banks behaviour. Landsman (2006) provides a comprehensive discussion on the advantages and disadvantages of fair value accounting, compared with the traditional asset valuation method based on historic cost. Based on a review on previous US-based empirical studies (Barth, 1994; Barth et al., 1996; Eccher et al., 1996; Nelson, 1996), Landsman (2006) concludes that on top of the book value, fair value provides incremental explanatory power in a bank's share price. It suggests that fair value accounting could provide additional information for investors, relative to historical cost accounting. This result is also supported by empirical evidence from Australia (Barth and Clinch, 1998) and the UK (Aboody et al., 1999; Lin and Peasnell, 2000).

On the other hand, Landsman (2006) also points out some potential issues relating to the implementation of fair value accounting in the banking sector. First, estimated fair value of financial assets might not be relevant and reliable, especially for those non-publicly-traded instrument where market price information is not available. This argument is supported by empirical evidence from two US-based studies focusing on corporate debt instruments (Barth et al., 1998, 2000). Second, given the fact that the fair value has to be estimated by manager's models for assets that are not publicly traded and market price are not directly available, Landsman (2006) argues that the manager of a bank has incentive to manipulate the model inputs when calculating the fair value of its non-publicly traded assets. This would have effects on the bank's stock price and capital ratio, which would potentially mislead investors and regulators. Third, Landsman (2006) suggests from a regulatory perspective that the estimated fair value of either bank assets or liabilities could contain measurement errors, which might generate excessive volatility in bank earnings and regulatory capital ratio. This argument is supported by the empirical findings from Barth et al. (1995) and Barth (2004).

In the aftermath of the great financial crisis, a major concern on fair value accounting is that whether the implementation of fair value accounting in the banking sector would cause excessive write-downs and contagions during a stressed period which would eventually lead to a banking crisis, given the fact that most of the impaired banking assets (asset-backed securities) during the crisis were marked-to-market.

Theoretically, it is possible that the financial condition of a bank could be negatively affected by fair value accounting for the following reasons. First, market prices of underlying assets might deviate from their fundamental values, either due to lack of liquidity in the market (Shleifer and Vishny, 1992) or limits of arbitrage (Shleifer and Vishny, 1997). Thus, fair value accounting which requires assets to be marked to market prices would generate a negative shock on banks given a sharp drop in the market price of certain assets held by those banks, even though the quality of these assets is not fundamentally deteriorated. Second, contagions in the banking sector are also possible due to fair value accounting. If a distressed bank sell a considerable amount of its financial assets at a fire sale price, other banks holding similar assets would receive a negative shock on their balance sheet if those assets are market to market, as they would have to revalue their assets based on the fire sale price. This would cause excessive write-downs to otherwise sound banks and drive down their capital ratios (Cifuentes et al., 2005; Allen and Carletti, 2008; Heaton et al., 2010). However, Laux and Leuz (2009)'s analysis suggests that even though fair value accounting is likely to exacerbate volatility in banks' financial statement, and mark-to-market approach in its pure form may cause contagion in the banking sector, historical cost accounting might not be an appropriate remedy. It suggests that the current prudential policies need to be adjusted to overcome the disadvantages of fair value accounting, rather than abandon this approach entirely.

Empirically, Khan (2010) examines the linkages between fair value accounting and systemic risks of the banking sector based on a sample of all listed US bank holding companies over the period from 1988 to 2007. It shows that the use of fair value accounting is positively associated with contagions risks in the banking system and this effect is more pronounced in a less liquid market environment. In addition, Khan (2010)'s cross-sectional analysis shows that this contagion effect are less likely to be transmitted to well-capitalised banks compared with those with a lower capital ratio, given a same level of use of fair value accounting. This empirical evidence is consistent with Allen and Carletti (2008)'s theoretical predictions on how fair value accounting could possibly amplify a banking crisis.

However, many argue that fair value accounting was not a contributor to the great financial crisis. Laux and Leuz (2010)'s analysis suggests that fair value accounting did not amplify the crisis for bank holding companies in the US for the following reasons. First, fair value assets only accounted for a small fraction on bank holding companies' balance sheet, while most of their assets were accounted for on a historical cost basis. Second, compared with book value, fair value is relevant even for assets that banks intend to hold for a long term, as it provides further transparency in the banking sector which benefits investors and regulators. Third, even though it might exacerbate volatility in banks' balance sheet during normal periods, the transparency provided by fair value accounting could mitigate information asymmetry and reduce uncertainty in the banking sector, which might have alleviated the severity of the crisis. Fourth, the effects of depreciation in fair value of banking assets on banks' earnings and capital ratios were shielded by regulatory filters, which means that the fair value accounting approach in practice is not in its pure form as assumed in the theoretical models by Allen and Carletti (2008). Barth and Landsman (2010)'s analysis reaches a similar conclusion that fair value accounting did not contribute to the financial crisis.

Shaffer (2010)'s empirical exercises focus on large US banks over the crisis period, as small banks had a negligible amount of assets accounted for on a fair value basis. Its empirical results suggest there is no clear links between use of fair value accounting and regulatory capital ratio for the sample banks during the crisis period. Furthermore, the empirical evidence provided by Kolev (2008), Song et al. (2010), and Goh et al. (2015) on market pricing of banks' fair value assets do not suggest that fair value accounting approach have caused excessive write-downs during the great financial crisis. In addition, Basel Committee on Banking Supervision (2017)'s review on existing studies on the effect of fair value accounting on bank behaviours over the crisis period concludes that there is no clear evidence that fair value accounting may lead to contagion in the banking sector. Overall, these empirical evidence are consistent with the argument that fair value accounting did not play a significant role in the crisis.

To sum up, previous papers in the literature have deeply investigated the motivation of a bank to increase its sovereign exposure during sovereign distress period, and explored the possible crowding-out effect of the bank's home-bias on private credit supply. Moreover, the effect of bank's sovereign exposure on its credit supply given a sovereign shock has been widely tested using data from various sources and many different measurements on bank's sovereign exposure. The capital channel and funding channel have been proposed in the literature to rationalise this adverse effect.

However, the heterogeneity among different types of bank's sovereign exposures[3] has yet been fully explored in the literature. There is no consensus in the literature yet whether fair value accounting could cause excess negative impact on a bank's financial condition. In addition, there is still no convincing empirical evidence on the transmission channels through which the bank's sovereign exposure can negatively affect bank lending during the sovereign crisis period. Thus, the central theme of this chapter is to identify the following issues with a robust empirical strategy: 1) the adverse effect of sovereign exposure on bank lending; 2) the heterogeneity among different types of sovereign exposure; and 3) the transmission channels of the adverse effect, more specifically, the capital channel and the funding channel, where point 2 and 3 fill gaps in the literature.

[3]For instance, exposures that are marked to market vs. accounted for at historical cost, short-term vs. long-term exposure, or domestic vs. foreign exposure.

3.3 Transmission Mechanisms and Hypotheses

This section describes the difference among bank's sovereign exposure with different accounting classifications. This is important for the analysis as different accounting and regulatory treatment on various types of sovereign exposure could have different economic impacts.

A bank can be exposed to a sovereign in several ways: it can make a loan to a sovereign; it can own a government bond; or it can enter into a derivative contract where the counterparty is a sovereign or the underlying asset is a government bond. These ways are treated differently from each other in accounting standards, in how those standards are reflected in prudential regulation, and in regulatory capital requirements. Table 3.1 summarise the main difference of different categories of banks' sovereign exposures.

The key difference in accounting standards is between those exposures that are valued on a historical cost basis and those valued on a fair value basis. Loans and government bonds that a bank intends to hold to maturity (HTM) are valued on a historical cost basis, which means that any sovereign distress which falls short of the sovereign defaulting does not change the value of those exposures on a bank's balance sheet. Whereas exposures that are fair valued are valued using current market prices; this means changes in market prices resulting from sovereign distress will reduce the value of those exposures on a bank's balance sheet and create a loss that is deducted from a bank's equity. Bonds that are classified as available for sale (AFS), held for trading (HFT), or under the fair value option (FVO), and derivatives are fair valued.

Table 3.1: Sovereign Exposure in Different Accounting Classification

Items	Accounting Treatment			Regulatory Treatment
	Classification	**Valuation**	**Impact of sovereing distress**	
Loan & Advances	HTM	Historical Cost	No change in value if a sovereign does not default. If a sovereign defaults, any losses are accounted for in a bank's profit and loss account, which are deducted from a bank's equity.	0% risk-weight
Government Bonds	HTM	Historical Cost		
	AFS	Fair Value	Changes in the market value are reflected in a bank's AFS reserves, which is part of a bank's equity. Jurisdictions adopt different approaches to how changes to the AFS reserves are reflected in a bank's regulatory capital (see Appendix Table A3.1)	
	FVO	Fair Value	Changes in the market value are reflected in a bank's profit and loss account.	Capital Must be held against the market risk
	HFT	Fair Value		
Derivatives	HFT	Fair Value		

Notes: HTM stands for Held to Maturity, AFS for Available for Sale, FVO for Fair Value Option, and HFT for Held for Trading.

There are several differences in the regulatory treatment of these exposures. In the EU during the period we look at, loans and bonds that are HTM and AFS received a 0% risk weight, which implies banks were not required to have capital against those exposures. [4] Although changes in the fair value of AFS exposures are reflected in a bank's equity, there were differences both across time and EU member states in whether those fair value changes were filtered out of a bank's regulatory capital (i.e. the capital used to calculate its regulatory capital ratios). Focusing on losses, before 2014 regulators in member states applied different filters. Under the Basel III reforms to bank regulation, any filters applied to losses on AFS exposures were to be phased out between 2014 and 2018. Some member states gradually phased out the filters, but others had removed the filters completely from 2014 (see Appendix Table A3.1). Changes in the fair value of FVO and HFT bond, and derivative exposures flow straight through to both book and regulatory capital. And banks are required to hold capital against the market risk associated with those exposures.

Differences in accounting treatments could affect how big an impact sovereign distress has on a bank. For instance, if a sovereign is in distress but has not defaulted a bank does not have to change the value of its bonds issued by that sovereign if those bonds are classified as historic cost exposures (e.g. HTM), but it does have to change the value - to reflect the fall in the bond price - if the bonds are classified as fair value exposures (e.g. AFS, FVO or HFT).

[4] Under the EU Capital Requirements Regulation, government debt denominated in a government's own currency receives a 0% risk weight under the standardised approach to credit risk (European Commission (2013)).

Table 3.2: Transmission Mechanisms of Sovereign Exposure: an example

Panel 1: balance sheet before the sovereign shock

Bank A

Assets		Liabilities	
Cash/Reserves	10	Deposit	70
Government Bonds		Interbank	10
- HTM	10		
- AFS	5		
- HFT	5		
Loans	70	Equity	20
Total	100	**Total**	100

Bank B

Assets		Liabilities	
Cash/Reserves	10	Deposit	70
Government Bonds		Interbank	10
- HTM	5		
- AFS	10		
- HFT	5		
Loans	70	Equity	20
Total	100	**Total**	100

Negative Sovereign Shock (-40%) ⇓

Panel 2: balance sheet after the sovereign shock

Bank A

Assets		Liabilities	
Cash/Reserves	10	Deposit	70
Government Bonds		Interbank	10
- HTM	10		
- AFS	3		
- HFT	3		
Loans	70	Equity	16
Total	96	**Total**	96

Bank B

Assets		Liabilities	
Cash/Reserves	10	Deposit	70
Government Bonds		Interbank	10
- HTM	5		
- AFS	6		
- HFT	3		
Loans	70	Equity	14
Total	94	**Total**	94

Table 3.2 presents an numerical example on this specific issue with two simplified bank balance sheets. Panel 1 in Table 3.2 presents the balance sheet for two banks before a sovereign shock occurs. Assuming the main structure of bank A and bank B are essentially the same: both banks start with 100 unit of total assets where 10% are

allocated as cash or central bank reserves, 20% are invested in identical government bonds issued by a single sovereign, and 70% are outstanding loans; on the other side, 70% of the banks' liabilities are customer deposits, 10% are borrowed from the interbank market, while equity accounts for 20% of the total liabilities. However, the only difference between the two banks is how the sovereign exposures are classified on their balance sheets. Bank A classifies 10 units of their sovereign exposure as HTM, 5 units as AFS, and 5 unites as HFT, while bank B, hold 10 units of its sovereign exposure as AFS, 5 units as HTM, and 5 units as HFT.

Now assuming that a specific shock hits the sovereign the two banks are exposed to, and the market value of the government bonds dropped by 40%. Due to the difference between the accounting treatments of sovereign exposures, the two banks would be differently affected, and the balance sheet for the two banks after the sovereign shock are presented by Panel 2 in Table 3.2. As HTM exposures are valued based on historic cost, bank A's HTM exposure would remain at 10 units, while the value of the bank's AFS and HFT exposures would drop by 40% to 3 units. The drop in the value of the bank's AFS exposures would be directly reflected by a drop in the bank's equity (assuming no regulatory filter applies), while the change in the value of HFT exposures would be realised through profits/losses then finally reflected by a change in the bank's equity. Overall, bank A's equity dropped from 20 units to 16 units due to the sovereign shock. The impact of the sovereign shock would be greater for bank B, as more sovereign exposures are classified as AFS assets where the value has to be marked to market. After the adjustment, bank B's equity would drop from 20 units to 14 units, which is strictly lower than bank A's equity in this sovereign distress scenario, thus one may expect that bank B tend to restrict their lending activity by more to maintain its regulatory capital at a certain level, compared with bank A. This example clearly shows that how the different accounting classifications and valuation methods of banks' sovereign exposures would affect the capital channel through which a sovereign shock would have an impact on banks.

Thus, the impact of the sovereign shock, via the capital channel, might be weaker if a bank's exposure to the distressed sovereign are accounted for on a historic cost basis than if its holdings are accounted for on a fair value basis. This mechanism is developed as a key hypothesis to be tested in our research.

- HYPOTHESIS 1. *Given a negative sovereign shock, a bank's lending activities would be more affected if more of the bank's impaired sovereign exposures were accounted for on a fair value basis, instead of historic cost basis.*

Furthermore, accounting treatments also have implications for the capital requirements associated with sovereign exposures. If an exposure is HTM or AFS, a banks is typically not required to hold any capital against the credit risk (i.e. the risk the sovereign defaults) it is exposed to. In the EU, there is a 0% risk weight for credit risk for exposures to all EU sovereigns. But if an exposure is HFT or FVO, a bank is required to hold capital against the market risk (i.e. the risk the market value falls) it is exposed to. Taking Bank A in Table 3.2 as an example. Bank A has exactly the same amount of AFS and HFT exposures (5 units each) prior to the sovereign shock, where regulatory capital is required for HFT exposures but not for for AFS exposures. Though the sovereign shock triggered a loss of 2 units exposures for both AFS and HFT accounts, one may expect that the 2 units drop in the AFS exposure might have a greater impact on the bank's lending activity than a 2 units drop in the value of HFT exposures, as the potential losses from the change in the market value of the HFT exposure were buffered with certain amount of regulatory capital.

Thus, the impact of a sovereign's distress might be weaker if a bank's exposure if HFT or FVO because a bank has some capital against the risk of incurring losses on those exposures than if its exposures are HTM or AFS. In other words, if a bank is required to hold capital against an exposure, the shock of a sovereign getting into distress may be smaller. This puts forward the second key hypothesis in our research.

- HYPOTHESIS 2. *The impact of a sovereign shock on bank lending activities could be alleviated if certain level of regulatory capital were required to be held against the impaired sovereign exposures.*

3.4 Data

The main focus of this research is to test the effect of a bank's sovereign exposure on its lending activity during sovereign distress period, then explore the heterogeneity among different types of the sovereign exposure which could be decomposed according to the classification category, residual maturity and counter-party. Furthermore, it tests the two hypothesised transmission channels - capital and funding channel through bank's sovereign exposure. To do this, it combines the data collected from multiple sources: granular data on bank's sovereign exposure disclosed by EBA stress tests and exercises; bank balance sheet and income statement information from SNL database; and country-level variables collected from Bloomberg, Datastream and Moody's. Detailed information on the data used in the econometric analysis is described by the rest of this section.

3.4.1 EBA Sovereign Exposure Data

The sovereign exposure data for the banks in the analysis comes from the disclosure of a series EU-wide stress tests and exercises conducted by the European Banking Authority (EBA) since 2010. One of the purposes of these exercises is to test the stability of the European banking system facing the sovereign debt crisis. Thus, detailed information on banks' sovereign exposures has been collected as part of the exercises, in order to estimate the potential adverse effect of those exposure on banking stability.

Table 3.3 summarises the main characteristics of the sovereign exposure datasets provided by EBA. The first column of Table 3.3 presents the name of exercises while the second column shows the dates when the data were collected. From the second column, one can observe that the sovereign exposure data are not collected at a regular intervals, but they are collected at very close to a semi-annual frequency.

The sample period starts from the first quarter of 2010 when the crisis had started, and ends at the last quarter of 2016. Thus, it covers information on bank's sovereign exposure for both crisis and post-crisis periods. The number of EU banks participated in those exercises is presented in column 3. As it shows, the sample initially covers 90+ banks in the first two stress tests, then the number decreases to 60+ in the following capital and transparency exercises from 2011 to 2013. It bounces back to 123 banks in the 2014 stress tests but shrinks to 51 in the latest stress test in 2016.

The sample size varies across different exercises mainly due to two reasons. First, the data are collected for exercises focusing on different specific issues, thus EBA adjusted its sampling criteria across those exercises. For example, the number of participant banks decreases to 65 in the 2011 capital exercise from 90 in the stress test conducted earlier in the same year because the EBA capital exercise was only focused on the very big banks in the European banking system. Second, the number of banks in EU countries changes overtime as a result of mergers and acquisitions in the banking sector (eg. the Spanish banking consolidation). For example, the sampling criterion for 2010 and 2011 stress tests was to cover 60 percent of the total banking assets in each EU country. As a result, the sample size was 91 and 90 respectively. However, the 51 banks participated in the latest stress test in 2016 covered over 70 percent of the total banking assets in the EU countries. Though the number of banks varies across the datasets, most of the major European banks have been covered by all the EBA exercises, which means that the sample of the panel dataset is still representative.[5]

[5]See a list of the sample banks in the appendix.

Table 3.3: Summary of EBA Sovereign Exposure Datasets

			Sovereign Exposure Breakdown by		
EBA Exercise	**Data Date**	**No. of Banks**	**Category**	**Maturity**	**Counter-party**
Stress Test 2010	2010 Q1	91	No	No	30 European Countries
Stress Test 2011	2010 Q4	90	Yes	Yes	30 European Countries
Capital Exercise 2011	2011 Q3	65	Yes	Yes	30 European Countries
Capital Exercise 2012	2011 Q4 2012 Q2	62	Yes	Yes	30 European Countries
Transparency Exercise 2013	2012 Q4 2013 Q2	64	Yes	Yes	30 European Countries + HK, JP, CH, US, AU, CA
Stress Test 2014	2013 Q4	123	Yes	Yes	30 European Countries + HK, JP, CH, US, AU, CA, CN, HR
Transparency Exercise 2015	2014 Q4 2015 Q2	105	Yes	Yes	30 European Countries + HK, JP, CH, US, AU, CA, CN, HR
Stress Test 2016	2015 Q4	51	Yes	Yes	30 European Countries + HK, JP, CH, US, AU, CA, CN, HR

Notes: Category denotes the accounting classification for banks' sovereign exposure, which includes held to maturity (HTM), available for sale (AFS), fair value option (FVO), held for trading (HFT), loan and advances, and derivatives. Maturity denotes the residual maturity of a bank's sovereign exposure.

Compared with other data sources, an advantage of the EBA sovereign exposure datasets is that they provide very detailed information on bank's sovereign debt holdings. As indicated by the last three columns in Table 3.3, one can observe a bank's exposure to a specific sovereign with a specific residual maturity, classified in a specific accounting category. More specifically, in terms of the category breakdown, it provides information on how much of the bank's sovereign exposure is classified into the following categories: HTM, AFS, FVO, HFT, and derivatives. Given the different regulatory treatments of these categories of sovereign exposure as described previously, they may have different effects on a bank during a sovereign crisis.

The sovereign exposure is decomposed by the following range of the residual maturity: less than 3-months, 3-months to 1-year, 1-year to 2-year, 2-year to 3-year, 3-year to 5-year, 5-year to 10-year, 10-year to 15-year, and more than 15-year. It is usually considered that short-term sovereign exposures tends to be less risky then long-term exposure. However, the relative perceived riskiness can be very different during the sovereign crisis period. As a distressed government tend to have more trouble with meeting its debt obligations maturing in the nearer term, bank's short-term sovereign exposure can have much more risk than the long-term exposure to the same sovereign, during the sovereign distress period. For example, the slope of the Greek bond yield curve became negative at the peak of the crisis, which clearly shows a higher risk of short-term debts. Thus, this study takes the advantage of the granularity of the datasets to explore the difference between bank's short-term exposures and long-term exposures.

For the information on counter-party countries, as the last column of Table 3.3 shows, the EBA disclosed banks' exposure to 30 European countries in its first four exercises. Then the list was extended to include six more countries/areas outside of the EU during the 2013 transparency exercise, and further extended to include bank's exposure to China and Croatia since the 2014 stress test. Given the fact that regulatory authorities tend to give a lower risk-weight on a bank's domestic sovereign exposure compared with exposure to foreign countries, the analysis also tests the different effect of domestic exposure and foreign exposure, using the counter-party information provided by the datasets.

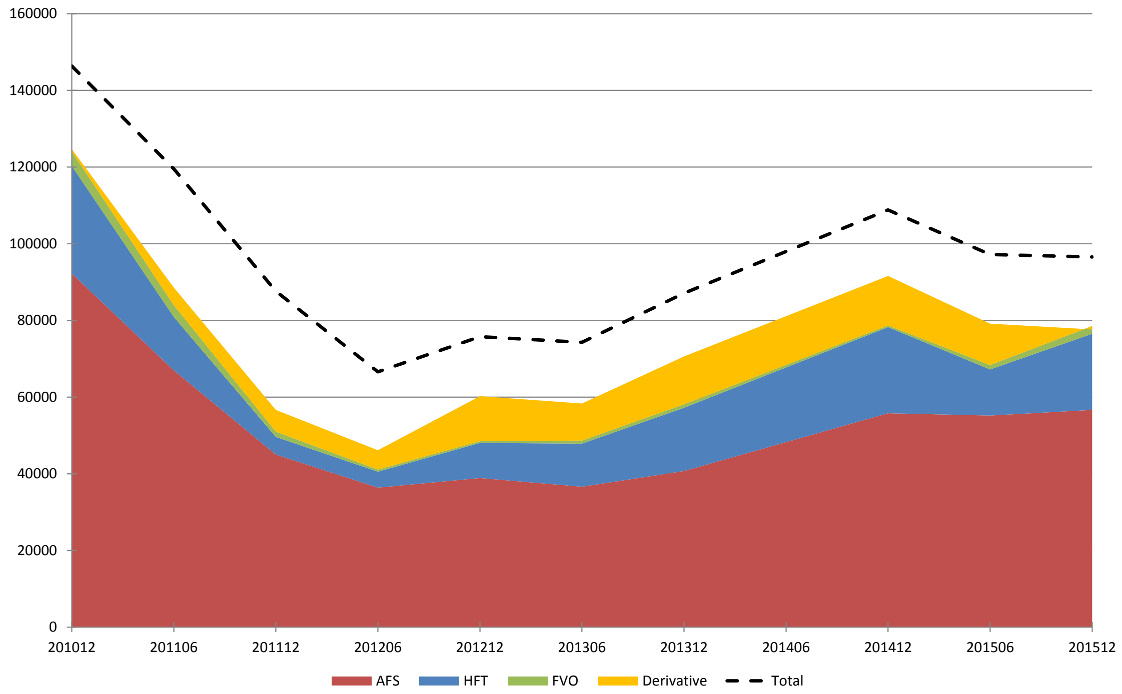
Overall, the granularity of the datasets allows it to explore the heterogeneity among different types of bank's sovereign exposures from three aspects: accounting category, residual maturity and counter-party country. As Table 3.3 shows, the first EBA sovereign exposure dataset does not have the decomposition of the exposure by category and maturity, thus the sample period of the main analysis starts from the 4th quarter of 2010.

Figure 3.1 shows an example of the information we could directly observe from the EBA sovereign exposure datasets.[6] The dashed line in the graph shows the trend of non-GIIPS banks' total exposure to GIIPS debts over the sample period from 2010 Q4 to 2015 Q4. The total exposure is decomposed by its accounting category below the dashed line, where the gap between the dashed line and the areas is the amount of HTM exposure. It clearly shows that the amount of non-GIIPS banks total exposure to GIIPS country has dropped significantly since 2010 as the crisis erupted. Two other facts can also be observed from the decomposed exposure. First, the AFS exposure accounts for at least around half of the total exposure at all times during the sample period. Second, the decrease in the total exposure in the early stage of the crisis is mainly due to the decrease in the AFS exposure. Notice that the significant drop in AFS exposure could be due to two reasons: 1) banks may be selling these AFS assets at the early stage of the crisis trying to prevent their capital to be affected by the potential further devaluation in

[6]To transform the datasets to have a semi-annual frequency, linear interpolation has been conducted for 2011Q2 and 2014Q2 as sovereign exposure data are not available for these two dates. The trend in the graph is based on a balanced panel to avoid inconsistency.

Figure 3.1: Non-GIIPS Banks' Exposure to GIIPS Debt

breakdown by accounting classification, Euro(millions)



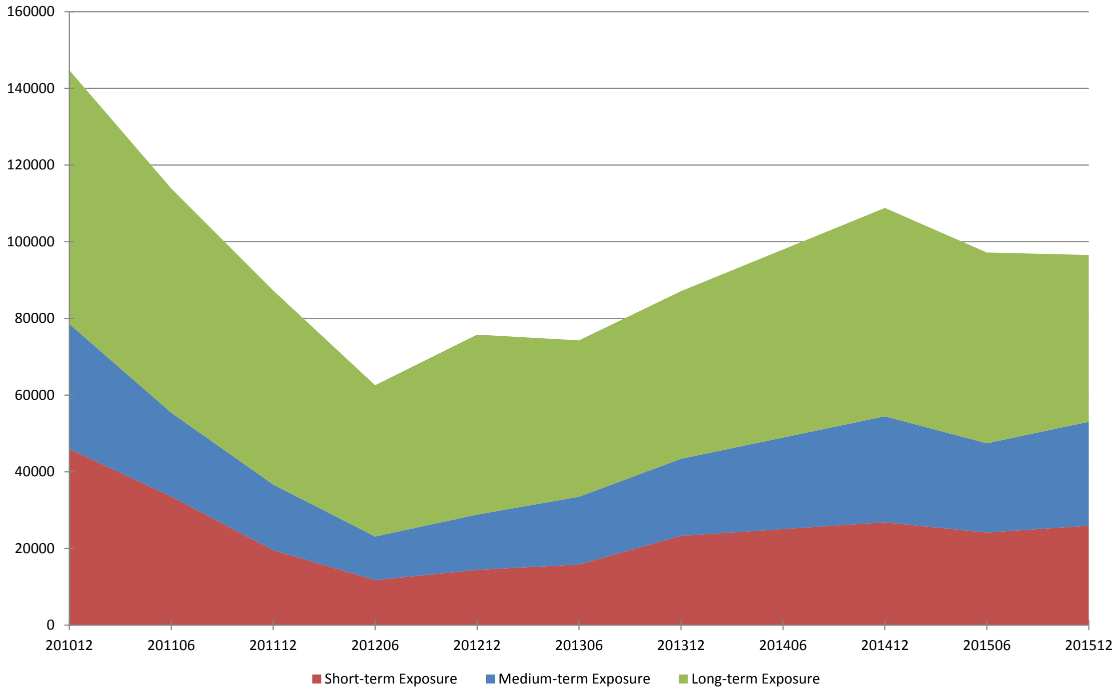
Source: European Banking Authority
Notes: This figure shows an example of the information we could directly observe from the EBA sovereign exposure datasets. The dashed line in the graph shows the trend of non-GIIPS banks' total exposure to GIIPS debts over the sample period from 2010 Q4 to 2015 Q4. The total exposure is decomposed by its accounting category below the dashed line, where the gap between the dashed line and the areas is the amount of HTM exposure. Linear interpolation has been conducted for 2011Q2 and 2014Q2 as sovereign exposure data are not available for these two dates. The trend in the graph is based on a balanced panel to avoid inconsistency.

their AFS assets; 2) apart from that, it maybe just because the market value of the AFS assets is decreasing as they are marked to market.

The non-GIIPS banks' total exposure to GIIPS debts is decomposed by the residual maturity of the debts in Figure 3.2, where short-term is defined by maturity less than 2-year; medium-term is defined by the range of 2-year to 5-year; and long-term is everything above 5-year. As it shows, the drop in the total exposure before the year of 2012 is mainly due to the decrease in banks' short-term and medium-term exposure. Again this could be for two reasons: banks were selling off these short-term and medium-term assets as they tend to be riskier; or the market value of those short-term and medium-term debts significantly dropped thus driving down

Figure 3.2: Non-GIIPS Banks' Exposure to GIIPS Debt

breakdown by residual maturity, Euro(millions)



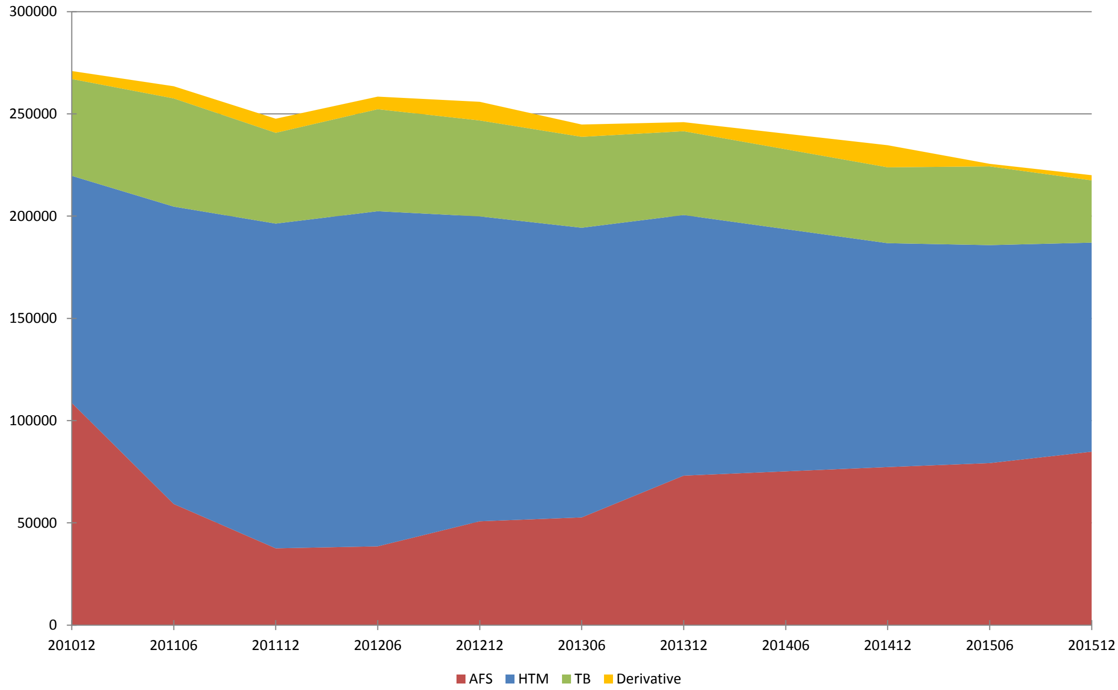
Source: European Banking Authority
Notes: This figure shows the decomposition for non-GIIPS banks' total exposure to GIIPS debts based on the residual maturity. Short-term is defined by maturity less than 2-year; medium-term is defined by the range of 2-year to 5-year; and long-term is everything above 5-year. Linear interpolation has been conducted for 2011Q2 and 2014Q2 as sovereign exposure data are not available for these two dates. The trend in the graph is based on a balanced panel to avoid inconsistency.

banks' exposures.

Figure 3.3 illustrates another example showing the trend of the total sovereign exposure of the German banking system over the sample period, decomposed by accounting category. Though the German banks' total sovereign exposures decreases over time, the overall trend is quite flat. However, the decomposition of the total exposure shows that German banks significantly reduced their AFS exposure while added to HTM exposure in the early stage of the crisis, keeping the total amount of exposure relatively stable. Given this fact, one may consider that those German banks were actually reclassifying their AFS assets into HTM category. We further decompose German banks' exposure in different category by its counter-party countries: GIIPS versus non-GIIPS. There is no evidence that the decrease in AFS

Figure 3.3: German Banks' Total Exposure

breakdown by accounting classification, Euro(millions)



Source: European Banking Authority
Notes: This figure shows the trend of the total sovereign exposure of the German banking system over the sample period, decomposed by accounting category. Linear interpolation has been conducted for 2011Q2 and 2014Q2 as sovereign exposure data are not available for these two dates. The trend in the graph is based on a balanced panel to avoid inconsistency.

exposure and increase in HTM exposure is because banks were selling off GIIPS debts in AFS category while buying in core-country's debt, which confirms the reclassification hypothesis. As the reclassification behaviour only happened during the crisis period, this is evidence that bank's AFS exposure can be very different from HTM exposure during sovereign distress period.

These examples illustrate the main feature of the EBA sovereign exposure datasets and the basic facts that could be extracted from those data. The main analysis combines the EBA datasets with other bank-level and country-level variables to formally answer the research questions of this essay.

3.4.2 Bank-level Financial Data

Apart from the sovereign exposure data, other bank-level information is collected for the banks participated in the EBA exercises from the SNL Financial database which provides high quality data for the financial firms with a quarterly frequency. It follows Gennaioli et al. (2014a) and uses bank's loan growth rate as a measurement of bank's lending activity. Data are also collected for the following items to control their effect on bank's loan growth: bank size measured by the logarithm of bank's total assets; bank capital measured by a series of regulatory capital ratios and proxies for leverage ratio; liquidity captured by bank's total liquid assets as a ratio of total assets; profitability measured by bank's return on assets; and interbank ratio measured by bank's interbank lending scaled by its interbank borrowing. All bank-level variables described above are collected with a quarterly frequency, which gives us a panel dataset with 1,248 observations for 78 banks over the period from 2010Q4 to 2015Q4. The summary statistics of these variables is presented in the first panel in Table 3.4.

Table 3.4: Summary Statistics

	(1)	(2)	(3)	(4)	(5)
Variables	**N**	**Mean**	**St.D.**	**Min**	**Max**
Bank Level					
Loan Growth	1,248	-0.254	3.556	-14.57	17.22
Size	1,248	11.89	1.513	8.343	14.73
CET1 Ratio	1,248	12.09	3.366	1.83	28.69
Liquidity	1,248	88.99	105.7	8.455	983.8
Profitability	1,248	-0.0115	1.449	-7.38	2.45
Interbank Ratio	1,248	67.83	75.86	0.38	806.2
Sovereign Holding Position					
Total Position	1,248	22.53	12.8	-10.51	63.59
HTM Position	1,248	8.283	9.165	-0.62	52.15
AFS Position	1,248	11.22	9.364	0	52.13
TB Position	1,248	2.915	4.519	-1.346	41.81
Derivative Position	1,248	0.0979	1.117	-13.1	8.858
Short-term Position	1,248	4.559	3.641	-1.879	22.22
Medium-term Position	1,248	2.899	2.362	-2.447	11.57
Long-term Position	1,248	3.799	3.269	-1.701	17.01
Domestic Position	1,248	7.171	6.161	-0.0672	31.03
Foreign Position	1,248	4.098	4.547	-6.644	23.84
Country Level					
GDP Growth	1,248	0.671	2.428	-10.73	8.23
Unemployment Rate	1,248	12.06	6.628	3.07	27.83
Inflation Rate	1,248	1.116	1.449	-2.2	6
Depreciation	1,248	1.031	4.864	-33.33	25
Gov. Bond Yield	1,248	3.777	5.091	0.19	41.74
Number of Banks	78	78	78	78	78

The second panel of Table 3.4 shows the summary statistics for the sovereign debt holding positions from the EBA datasets, scaled by the banks' total assets collected from SNL database. As it shows, it also calculates the decomposed sovereign debt holding by its category, maturity and counter-party respectively. These variables are also controlled in the corresponding regressions of the econometric analysis.

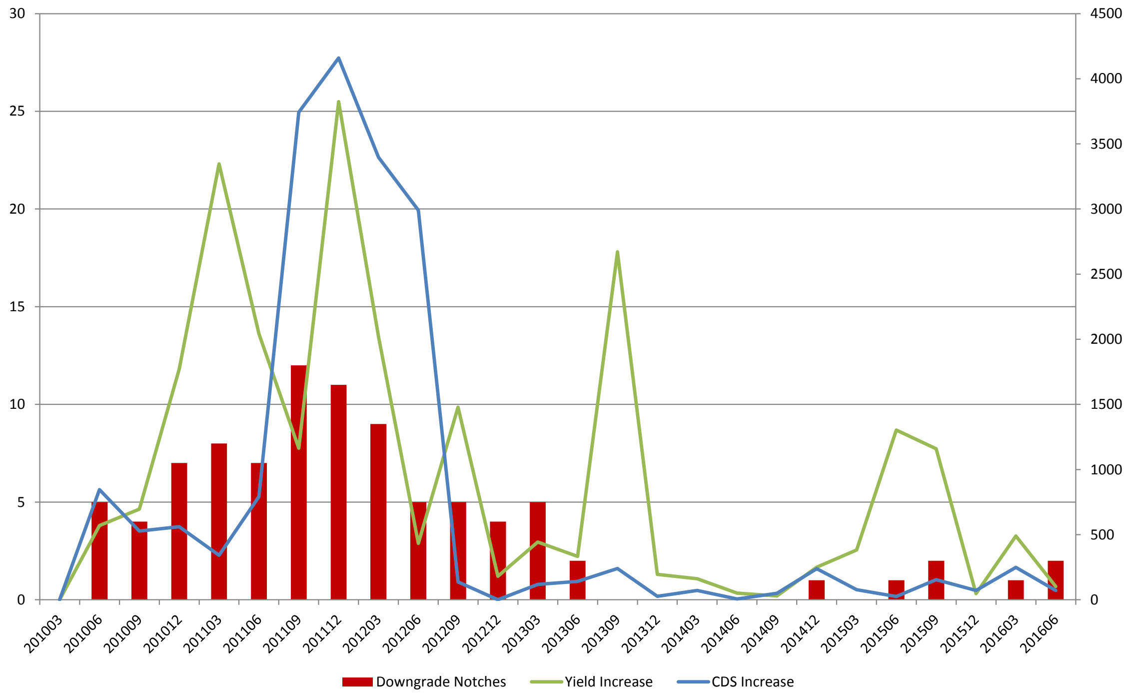
3.4.3 Sovereign Shock Indicator

The main idea of this essay is to analyse a bank's sovereign exposure on its lending activity during a sovereign crisis, thus data are collected for sovereign ratings, government bond yield and CDS spread to indicate specific sovereign shocks during the sample period. Following Adelino and Ferreira (2016), it uses sovereign downgrades as the primary sovereign shock indicator in the analysis. Sovereign rating data is collected from one of the main rating agencies - Moody's for the 30 European and 8 non-EU counter-party countries disclosed by the EBA sovereign exposure datasets. Downgrade notches are calculated for these countries in each quarter, to match the quarterly frequency of the bank-level panel dataset.

It also calculates the increase in the quarterly average of government bond yield and CDS spread as alternative sovereign shock indicators for the same group of countries. However, the quarterly downgrade notched is the preferable indicator as it shows clear sovereign shocks in each specific country in each quarter, while the data of the government bond yield and CDS spread can be very volatile within a quarter, especially during the crisis period. Using the increase in the quarterly average of the market data as indicators can either miss information or capture something else rather than the sovereign shock.

The trend of the aggregate quarterly sovereign shocks for the 30 European countries and 8 non-EU countries over the sample period is presented in Figure 3.4. The aggregate sovereign downgrade notches as the primary sovereign shock indicators are depicted with bars while the alternative indicators are presented with lines, where the CDS spread indicator is labelled with the vertical axis to the right. All of the three indicators consistently show that the European sovereign debt crisis was peaked during the second half of 2011. However, it clearly shows that the indicators based on bond yield and CDS spread are much more volatile then the downgrade notches. In addition, there are some spikes in the indicator of bond yield in the later period of the crisis, which is not very consistent with the other two indicators.

Figure 3.4: Sovereign Shock Indicators



Notes: This figure shows the trend of the aggregate quarterly sovereign shocks for the 30 European countries and 8 non-EU countries over the sample period. The aggregate sovereign downgrade notches as the primary sovereign shock indicators are depicted with bars while the alternative indicators are presented with lines, where the CDS spread indicator is labelled with the vertical axis to the right. All of the three indicators consistently show that the European sovereign debt crisis was peaked during the second half of 2011. It also shows that the indicators based on bond yield and CDS spread are much more volatile then the downgrade notches.

3.5 Econometric Method

3.5.1 Bank Exposure to the Sovereign Crisis

This chapter tests the effect of a sovereign crisis on a bank's lending activity, given the bank's holding positions on the specific sovereign debts. To do this, a measurement is constructed to capture a bank's exposure to the sovereign crisis. Given the information on banks' holding positions on sovereign debts provided by the EBA datasets, the downgrading notches by Moody's as the primary sovereign shock indicator and the bank-level information collected from the SNL database, it combines the data from the 3 data sources and follow Popov and Van Horen (2015) and De Marco (2015) to construct the exposure measurement as the equation shows below

$$Exposure_{i,t} = \sum_{k} \frac{Position_{i,k,t-1} \times Shock_{k,t}}{Total\ Assets_{i,t-1}}$$

where

- i stands for each bank in the sample
- t denotes each quarter in the sample, ranging from 2010Q4 to 2015Q4
- $Position_{i,k,t}$ is bank i's holding position on country k's debts at time t, collected from the EBA datasets; it can either be the total holding position on a certain country, or the position decomposition by its accounting category, residual maturity, or counter-party country
- $Shock_{k,t}$ is the sovereign shock indicator for country k at time t, primarily the downgrade notches for each country from Moody's rating data
- $Total\ Assets_{i,t}$ is bank i's total assets at time t, collected from the SNL

database.

As the equation shows, the $Exposure_{i,t}$ captures bank i's exposure to the European sovereign debt crisis at time t, which is equal to the summation of bank i's sovereign debts holding position on each country in the previous time period, times its corresponding sovereign shock indicator in current period, then scaled by the bank's total assets. Furthermore, *Position* can either be the bank's total sovereign debts holding position, or the holding position decomposition by its accounting category, residual maturity or counter-party country, depending on the situation.

The following is an example of the application of the exposure measurement in a hypothetical scenario. Suppose a bank only holds sovereign debts issued by the 2 countries: country A and country B, and the sovereign distress happens in both countries, the bank's exposure to the sovereign debt crisis would be given by the following equation:

$$Exposure_t = \frac{Position_{A,t-1} \times Shock_{A,t} + Position_{B,t-1} \times Shock_{B,t}}{Total\ Assets_{i,t-1}}.$$

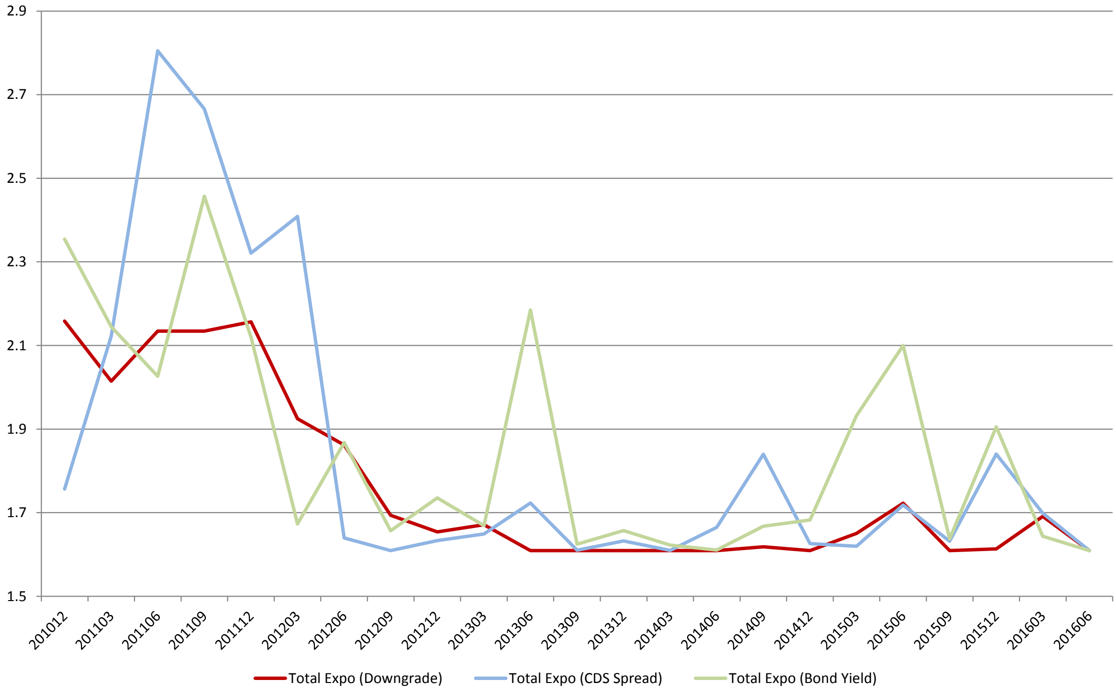
If the sovereign distress only happens in country A, the exposure measurement would be reduced to the equation below:

$$Exposure_t = \frac{Position_{A,t-1} \times Shock_{A,t}}{Total\ Assets_{i,t-1}}$$

where the bank's holding position on country B's debts would not be taken into account as there is no sovereign shock stemming from country B. Thus, the exposure measurement is actually a Difference-in-Difference term if one considers *Position* as a treatment and *Shock* as a indicator for treatment period.

Figure 3.5 shows the trend of the average of the bank's total exposure to the

Figure 3.5: Bank Exposure to Sovereign Shocks

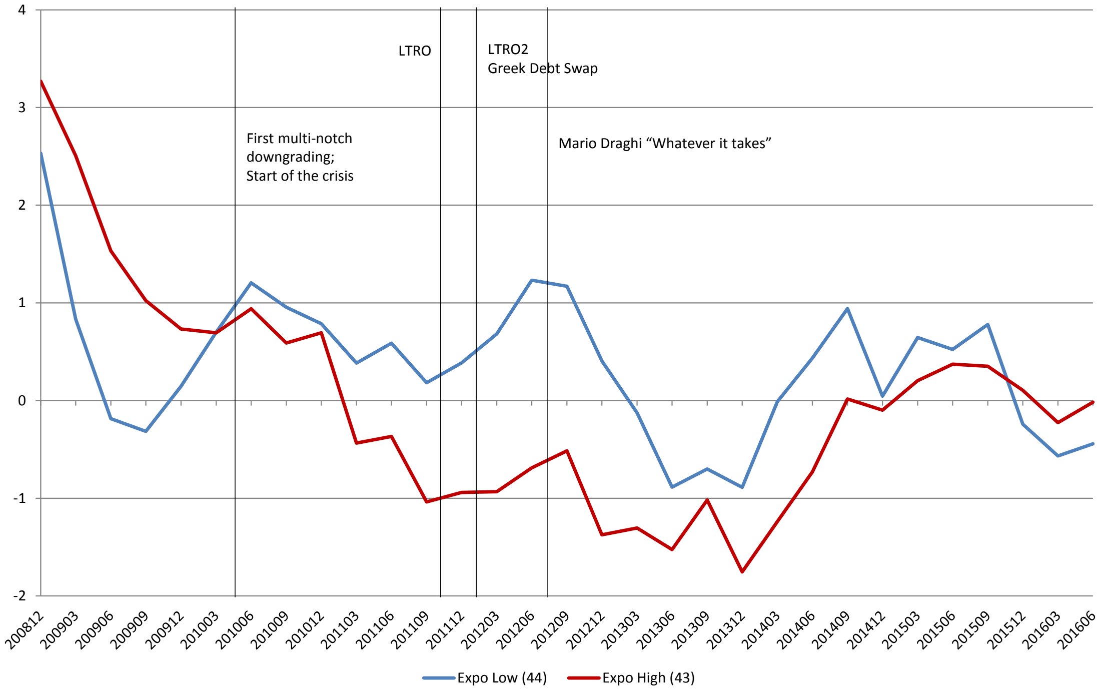


Notes: This figure shows the trend of the average of the bank's total exposure to the European sovereign debt crisis over the sample period, where the exposure measurements are generalised by taking logarithm. The red line in the graph denotes the trend of the exposure measurement constructed based on the downgrading notches which is the primary sovereign shock indicator, while the blue line and the green line depict the measurement based on CDS spread and government bond yield respectively. As the European sovereign debt crisis peaked in the second half of 2011, the average of the banks' exposure to the crisis also increases to the highest point, and this is consistent across the exposure measurements based on different sovereign shock indicators. It also shows that the measurements based on CDS spread and government bond yield are more volatile than the primary exposure measurement which is based on sovereign downgrade notches.

European sovereign debt crisis over the sample period, where the exposure measurements are generalised by taking the logarithm. The red line in the graph denotes the trend of the exposure measurement constructed based on the downgrading notches which is the primary sovereign shock indicator, while the blue line and the green line depict the measurement based on CDS spread and government bond yield respectively. As the European sovereign debt crisis peaked in the second half of 2011 as indicated by Figure 3.4, the average of the banks' exposure to the crisis also increases to the highest point, and this is consistent across the exposure measurements based on different sovereign shock indicators. It also shows that the measurements based on CDS spread and government bond yield are more volatile than the primary exposure measurement which is based on sovereign downgrade notches.

Figure 3.6: Average Trend of Loan Growth Rate

breakdown by exposure to the sovereign shocks



Notes: This figure shows the trend of the average loan growth rate for banks in two different groups separately, where blue line stands for the low exposed banks and red line for highly exposed banks. As it shows, before the start of the European sovereign debt crisis in early 2010, there is a common trend between the two groups of banks - the collapse of the banking credit supply due to the global financial crisis. The trends of loan growth for both groups bounce back in late 2009. However, the trends start to diverge as the European sovereign debt crisis erupts in 2010: highly exposed banks tend to have a lower loan growth rate than the low exposed banks as the crisis deepened in 2011. Moreover, it also shows that the two trends tend to converge in the later period of the crisis, indicating that bank's lending activity would not be affected if there are no further sovereign shocks.

Based on the average of the banks' exposure to the crisis over the sample period, the sample banks are equally separated into two groups: highly exposed banks with exposure higher than the median and low exposed banks with exposure lower or equal to the median. This gives us 43 banks in the low group and 43 in the high group. Figure 3.6 depicts the trend of the average loan growth rate for banks in the 2 groups separately, where blue line stands for the low exposed banks and red line for highly exposed banks. As it shows, before the start of the European sovereign debt crisis in early 2010, there is a common trend between the two groups of banks - the collapse of the banking credit supply due to the global financial crisis. The trends of loan growth for both groups bounce back in late 2009. However, the trends start to diverge as the European sovereign debt crisis erupts in 2010: highly exposed banks tend to have a lower loan growth rate than the low exposed banks as the crisis deepened in 2011. Moreover, it also shows that the two trends tend to converge in the later period of the crisis, indicating that bank's lending activity would not be affected if there are no further sovereign shocks. Controlling for other factors, this effect is formally tested in the following regression analysis.

3.5.2 Regression Specification

The main purpose of this essay is to answer the 3 research questions: first, can sovereign crisis have a negative effect on a bank's lending activity through the bank's exposure to the sovereign debts; second, can better bank strength alleviate the adverse effect of a sovereign shock where bank strength is measured by the level of bank capital and funding stability; and third, is there any heterogeneity among different types of sovereign exposure? These research questions are formally examined by the regressions with the following specifications.

The first step regression focuses on the first research question, and the specification is illustrated by the equation below.

$$\begin{aligned}\Delta Loan_{i,c,t} = \alpha_0 + \alpha_1 Exposure_{i,t-1} + \alpha_2 Strength_{i,t-1} \\ + \alpha_3 X_{i,t-1} + \alpha_4 X_{c,t} + \gamma_t + \gamma_i + \epsilon_{i,c,t}\end{aligned} \tag{3.1}$$

where

- i stands for each bank in the sample
- c denotes in which country the bank locates
- t denotes each quarter in the sample, ranging from 2010Q4 to 2016Q2

- $\Delta Loan_{i,c,t}$ is the loan growth rate of bank i in country c at time t
- $Exposure_{i,t}$ measures bank i's exposure to the sovereign debt crisis at time t, where the exposure can either be the total exposure to the sovereign crisis, or the exposure decomposition by the accounting category, residual maturity or counter-party country
- $Strength_{i,t}$ captures bank i's strength, mainly measured by capital ratios and funding stability ratios
- $X_{i,t}$ is a set of bank-level control variables
- $X_{c,t}$ is a set of macroeconomic control variables at country-level
- γ_t is time dummy variables controlling for quarter fixed effect
- γ_i controls for bank-level fixed effect
- $\epsilon_{i,c,t}$ is the error term for bank i in country c at time t.

As the equation shows, it controls for bank and country specific characteristics and bank-level and quarter fixed effect to investigate the effect of a sovereign shock on bank lending activities. The central hypothesis here is that the estimated coefficient on *Exposure*, α_1, is significantly less than 0, suggesting that a bank's lending activities would be negatively affected if the bank is exposed to the sovereign shocks.

For the second research question, an interaction term between *Exposure* and *Strength* is introduced into the baseline model, and the specification is illustrated by the equation below

$$\Delta Loan_{i,c,t} = \beta_0 + \beta_1 Exposure_{i,t-1} + \beta_2 Strength_{i,t-1} + \beta_3 Exposure_{i,t-1} \times Strength_{i,t-1} + \beta_4 X_{i,t-1} + \beta_5 X_{c,t} + \gamma_t + \gamma_i + \epsilon_{i,c,t} \quad (3.2)$$

The main hypothesis in this regression is that the estimated coefficient on the interaction term, β_3, is significantly greater than 0, as it is expected that bank strength would be helpful for banks to be more resilient to a sovereign shock. Indicating bank strength with capital ratios and funding stability ratios, the regressions at this stage would show implications for both capital channel and funding channel as transmissions between sovereign crisis and banking crisis.

For the third research question, a bank's exposure to the crisis is decomposed by the exposure's accounting category, residual maturity and counter-party country to test the heterogeneity among these different types of exposure. For example, a bank's total exposure is decomposed by the accounting category and all the following types of exposure are included into the regression: AFS exposure, HTM exposure, TB exposure and derivative exposure. The estimates on these terms are expected to differ from each other due to their different accounting and regulatory treatment. It is expected that AFS exposure would have a greater adverse effect as this types of exposure are marked to market while there is almost no capital requirement on these holdings. Furthermore, all these decomposed exposure terms are also interacted with the bank strength term to test their heterogeneity through capital channel.

3.6 Empirical Results

3.6.1 Baseline Results

The baseline results for the analysis are presented in Table 3.5, which answers the first research question whether bank lending could be affected by a sovereign shock if the bank is exposed to the shock through sovereign debt holdings. As Table 3.5 shows, the key term $Total\ Exposure$ is lagged for 1, 2 and 3 period in three separate regressions to test whether a sovereign shock would have a long lasting effect on bank lending, and the results for the three regressions are presented in column 1, 2 and 3 respectively. Bank-level and country-level variables are included in each regression to control for the effect of bank characteristics and macroeconomic demand-side effect of the bank's lending activity. In addition, bank and quarter fixed effect are also controlled in all regressions.

The first panel of Table 3.5 shows the estimated coefficient on the key terms. As it shows, the estimation on the 1-period-lagged term in the first column is positive but insignificant, which indicates that bank lending in current period would not be significantly affected by the sovereign shock occurred in the last quarter. However, the key term with a 2-period lag is estimated to be negative and significant in column 2. As $Total\ Exposure$ is generalised by taking logarithm, the interpretation of the estimated number is the following: 1 percent increase in a bank's exposure to the sovereign crisis would reduce the bank's lending growth rate by 0.975 percentage point in the second following quarter, which is not just statistically but also economically significant. The coefficient in column 3 is estimated to be a small negative number, indicating that the adverse effect of a sovereign shock on bank lending tend to last for 3 quarters. However this effect is not statistically significant. Overall, the estimation on the key terms indicates that a sovereign shock would have an

Table 3.5: Baseline Result - Effect of Sovereign Shock on Bank Lending

Dependent Variable: $\Delta Loan\%$	(1)	(2)	(3)
Total Exposure$_{t-1}$	0.216		
	(0.310)		
Total Exposure$_{t-2}$		-0.975**	
		(0.444)	
Total Exposure$_{t-3}$			-0.306
			(0.402)
Bank Level Controls			
Total Sovereign Position$_{t-1}$	-0.026	-0.032	-0.039*
	(0.023)	(0.023)	(0.023)
Size$_{t-1}$	-4.221*	-4.565**	-5.153*
	(2.495)	(2.220)	(2.984)
Loan to Assets Ratio$_{t-1}$	-0.127*	-0.164**	-0.161**
	(0.070)	(0.067)	(0.080)
CET1 Capital Ratio$_{t-1}$	0.062	0.075	0.078
	(0.091)	(0.092)	(0.096)
Liquidity$_{t-1}$	0.002	0.000	-0.001
	(0.003)	(0.002)	(0.002)
Interbank Ratio$_{t-1}$	0.003	0.002	0.002
	(0.002)	(0.003)	(0.003)
Return on Assets$_{t-1}$	0.260***	0.218**	0.176**
	(0.083)	(0.086)	(0.084)
Country Level Controls			
GDP Growth$_{t-1}$	0.117	0.092	0.249**
	(0.085)	(0.105)	(0.099)
Unemployment Rate$_{t-1}$	0.098	0.091	0.243*
	(0.084)	(0.102)	(0.122)
Inflation Rate$_{t-1}$	-0.365**	-0.235	-0.303
	(0.172)	(0.188)	(0.201)
Depreciation$_{t-1}$	-0.221*	-0.213*	-0.208*
	(0.126)	(0.124)	(0.112)
Gov. Bond Yield$_{t-1}$	0.077	0.099	0.115*
	(0.063)	(0.061)	(0.062)
Constant	5.159	11.015***	7.366
	(3.535)	(4.063)	(4.427)
Bank FE	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes
No. of Observations	1,112	1,041	971
No. of Banks	78	78	77
R^2	0.166	0.187	0.180

Notes: This table shows the baseline results of the analysis where the first panel shows the estimated coefficient on the key terms. It shows that the estimation on the 1-period-lagged term is positive but insignificant. However, the key term with a 2-period lag is estimated to be negative and significant in column 2: 1 percent increase in a bank's exposure to the sovereign crisis would reduce the bank's lending growth rate by 0.975 percentage point in the second following quarter. The coefficient in column 3 indicates that the adverse effect of a sovereign shock on bank lending tend to last for 3 quarters. Overall the baseline results suggests that a sovereign shock would have an adverse effect on a bank's lending activity if the bank is exposed to the shock by holding the the specific sovereign debts.

adverse effect on bank lending 2 quarters later. It expected that the negative effect of a sovereign shock can take 2 quarters to be reflected from a bank's lending activities for the following two reasons. First, banks will need to make accounting operations to realise its losses due to the sovereign shock, then adjust its lending activity as a response to the losses, and this process tend to take time. Second, the managers of a bank will need to make judgement on the strength and permanence of a sovereign shock based on other sources of information, so that they can confirm whether the sovereign shock is a permanent shock and adjust the bank's lending strategy accordingly. This process tends to take time because some shocks may be seen as temporary at the beginning while turn to be long-lasting/permanent as the crisis continues to deteriorate.

In terms of the estimations on the bank-level control variables, there are some consistent findings across the three models. Though bank's exposure to the crisis is estimated to be both statistically and economically significant, it does not show a robust and significant effect for a bank's total sovereign holding positions. Bank size tend to be negatively related with lending growth rate. Taking estimations from column 2 as an example, if a bank's total assets increase by 1 percent, the bank's lending growth rate would decrease by 4.565 percentage point. Loan to assets ratios is included in the model to control for the riskiness of the portfolio of a bank, and the estimations on this term are consistently estimated to be negative and significant: if the ratio of a bank increase by 1 percentage point, the bank's lending growth rate would decrease by 16 .4 basis points. Bank profitability is estimated to have a positive effect on bank's credit supply: a one percentage point higher return on assets would increase the bank's lending growth rate by 21.8 basis points in the next quarter. Besides, we do no find any significant effect of bank capital, liquidity and interbank funding position on bank lending at this stage.

Overall, the baseline results here shows that a sovereign shock would have an adverse effect on a bank's lending activity if the bank is exposed to the shock by holding the the specific sovereign debts. This result is consistent with the existing findings in the literature (Gennaioli et al., 2014a,b; Popov and Van Horen, 2015; De Marco, 2015).

3.6.2 Exposure Decomposition

Given the fact that the only the coefficient on the 2-period-lagged *Total Exposure* is estimated to be significant in the first stage, it then focuses on the model specification with a 2-period lag on the key terms in the following analysis. Based on the baseline results in the first stage, this section investigates the heterogeneity of the effect among different types of exposure by replacing the *Total Exposure* term with decomposed exposure, according to its accounting category, residual maturity and counter-party country. The decomposed sovereign debt holding positions are also included in corresponding regressions at this stage as control variables.

The regression results are presented in Table 3.6. The first column in Table 3.6 presents the baseline result estimated in the first stage analysis as a comparison. The *Total Exposure* is then decomposed by accounting category in column 2. As it shows, the only significant term is bank's derivative exposure: 1 percent increase in the exposure to the sovereign crisis in derivatives would reduce a bank's lending growth rate by 13.26 percentage points. Apart from that, it does not show a significant effect for a bank's AFS epxosure, HTM exposure and trading book exposure. The analysis on the transmission mechanism in Section 3.3 suggests that the negative effect of a bank's AFS sovereign exposure would be more significant for less-capitalised banks. Thus, the insignificant coefficient estimated on AFS exposure in column 2 might be driven by better-capitalised banks in the sample. The

Table 3.6: Decomposition of Total Sovereign Exposure

Dependent Variable: $\Delta Loan\%$		Exposure Breakdown by		
	Baseline	Category	Maturity	Counterparty
	(1)	(2)	(3)	(4)
Total Exposure$_{t-2}$	-0.975**			
	(0.444)			
AFS Exposure$_{t-2}$		-0.292		
		(0.578)		
HTM Exposure$_{t-2}$		-1.063		
		(0.744)		
TB Exposure$_{t-2}$		-0.032		
		(1.143)		
Derivative Exposure$_{t-2}$		-13.258**		
		(6.438)		
Short-term Exposure$_{t-2}$			-0.838	
			(1.169)	
Medium-term Exposure$_{t-2}$			0.503	
			(1.354)	
Long-term Exposure$_{t-2}$			-1.404	
			(0.958)	
Domestic Exposure$_{t-2}$				-0.904**
				(0.437)
Foreign Exposure$_{t-2}$				-0.422
				(1.104)
Bank Controls	Yes	Yes	Yes	Yes
Country Controls	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes
Observations	1,041	1,041	1,041	1,041
Number of bankid	78	78	78	78
R-squared	0.187	0.194	0.189	0.189

Notes: This table shows the regression results with the decompositions of banks' sovereign exposure, along with the baseline results in column 1. Refer to Table 3.5 for full specifications. The sovereign exposure is decomposed according to its accounting classification (AFS, HTM, TB), residual maturity (short, medium and long) and counterparty country (domestic and foreign) respectively in column 2, 3 and 4.

second stage analysis in the next section would further identify this capital channel. Overall, the results at this stage suggests that the adverse effect of bank's exposure to the crisis is mainly driven by the exposure in derivatives.

Then, the exposure is decomposed by residual maturity, and the result is presented in column 3 in Table 3.6. Though the total exposure is estimated to be negative and significant in the first stage, it does not show any significant effect with the exposure decomposition by maturity, as column 3 shows. It then tests the correlation among the decomposed exposure terms, as the insignificant result might be due to the correlation between these terms which could possibly increase the estimated standard errors. However the result of the test does not suggest a severe correlation between them.

Column 4 in Table 3.6 shows the result for the regression with exposure decomposition by counter-party country. As it shows, the *Total Exposure* is replaced with a bank's exposure to domestic sovereign shocks and its exposure to foreign shocks. The estimated coefficient is only significant on the domestic exposure while exposure to foreign shocks is estimated to have an statistically insignificant effect on bank lending. It suggests that one percent increase in the exposure to domestic sovereign shock would reduce a bank's lending growth rate by 0.9 percentage points 2 quarters later. Overall, this result suggests that a bank's exposure to the domestic sovereign crisis tend to have a greater adverse effect on the bank's lending activity.

3.6.3 Capital Channel and Interbank Funding Channel

In the first stage analysis, the results suggest that a sovereign shock can have a negative effect on bank's lending activity if the bank's balance sheet is exposed to the specific sovereign debt. This section investigates the reasons why the bank's exposure to the sovereign debt would have the adverse effect on the bank lending.

Two mechanisms has been proposed in the literature: capital channel and funding channel (Popov and Van Horen, 2015; De Marco, 2015). On one hand, the capital channel hypothesis argues that a value bank's sovereign debt holdings would decrease given a sovereign distress event, which would have a negative effect on bank's capital level. Bounded by the regulatory capital requirement, a bank has two options to maintain its capital ratio above the minimum requirement: issue new equity and cut its lending. However, given the fact that raising capital ratio by issuing new equity can be costly especially during a crisis period, banks tend to choose the latter option thus reduce its credit supply.

On the other, the funding channel hypothesis argues that the devaluation of the sovereign debts held by banks would reduce the banks' borrowing capacity in the wholesale funding market, as they usually use sovereign debts as collateral when entering a wholesale funding contract. During a sovereign debt crisis, a bank may not be able to sustain its lending activity if it is highly exposed to the sovereign debt meanwhile highly dependent on wholesale funding. Evidence has been provided that in the early stage of the European sovereign debt crisis, the Greek sovereign debts has been abandoned to be used as collateral in the interbank market (Drechsler et al., 2016). This section presents the results of the tests on both transmission channels.

In the second stage analysis, it tests the transmission channels by using the regressions specifications described by Equation 2. As it shows, a bank's exposure to the sovereign crisis is interacted with a strength indicator of the bank, where bank strength is measured by a series of regulatory capital ratio, leverage ratio and funding stability ratio to test the capital channel and funding channel.

To make the result clear and easier to be interpreted, dummy variables are generated based on these bank strength indicators. More specifically, the dummy variables for regulatory capital ratios would be equal to 1 if a bank's regulatory capital is greater than the corresponding minimum requirement plus the conservation buffer; otherwise 0. For example, the minimum requirement on a bank's CET1 capital ratio is 4.5% while the conservation buffer is 2.5%, thus a bank with a CET1 ratio higher than 7% would have a CET1 dummy equal to 1. The dummy variables for tier1 capital ratio and total capital ratio follow the same setting. In terms of the dummy variable for the interbank funding ratio, it equals to 1 if the ratio is greater than 100%, indicating that this bank is a net interbank lender; thus a net interbank borrower would have a dummy equal to 0. Other bank strength indicators includes synthetic leverage ratios measured by a bank's CET1 capital over total assets and total equity over total assets, and funding stability ratios measured by a bank's deposit funding over total assets and wholesale funding over total assets. For these bank strength indicators, the dummy variable would be equal to 1 if the ratio is greater than the 25th percentile level of the whole sample.

The results of the second stage regressions are presented in Table 3.7. The coefficient in the first column is estimated from the baseline regression without interaction terms and included in the table as a comparison. It suggests that a 1 percent increase in a bank's exposure to the sovereign debt crisis would reduce the bank's lending growth rate by 0.935 percentage points. However, this is the overall effect estimated for all banks in the whole sample. From column 2 onward, interaction terms between exposure and bank strength indicators are included into the baseline regressions. As it shows, once the interaction term is included, the estimated coefficient on $Total\ Exposure$ increases, and the coefficient on the interaction terms are all estimated to be positive and significant.

Taking results in column 2 as an example, the first number suggests that for banks with CET1 capital ratio lower than 7%, the lending growth rate would be 3.84

percentage points lower if its exposure to the crisis increase by 1 percent. Compared with the estimation from the baseline regression, the adverse effect of the sovereign shock is about four times larger on less capitalised banks. However, the estimated coefficient on the interaction term is 3.831, which means that the overall effect on the better capitalised banks would be -3.84 + 3.831, which would be very close to 0. This result suggests that the effect of a sovereign shock on the lending growth rate of the better capitalised banks would be economically insignificant. In other words, it suggests that the bank capital would alleviate the adverse effect of a sovereign shock on the bank lending. As the rest of the table presents, it also tests this effect with other capital ratios and leverage ratios, and the results are very consistent that the estimated coefficient on the interaction terms are all positive and significant. Overall, the findings provides robust evidence on the capital channel.

The funding channel is also supported by the results of these regressions. As the bottom part of Table 3.7 shows, the coefficients on the interaction terms between $Total\ Exposure$ and $Interbank\ Ratio$ are consistently estimated to be positive and significant. Though estimated number is small, it shows that a net interbank lender which is less dependent on the wholesale funding market tend to have a higher lending growth rate given a sovereign shock.This effect is also tested with other funding stability ratios, such as deposit funding over total assets and wholesale funding over total assets. However, there are no significant estimations on the interaction terms. Overall, the results supports the funding channel hypothesis. Though the effect is only significant for interbank ratio while not significant for other indicators, it argues that the interbank ratio should be consider as the primary indicator as it shows the net position of a bank which can better capture the bank's reliance on the wholesale funding market.

Table 3.7: Transmission Channels: Capital and Interbank Funding

Dependent Variable: $\Delta Loan\%$	(1)	(2)	(3)	(4)	(5)	(6)
Total Exposure$_{t-2}$	-0.935**	-3.840**	-3.787**	-2.948*	-1.980	-1.735
	(0.433)	(1.576)	(1.491)	(1.646)	(1.601)	(1.694)
Total Exposure$_{t-2}$ * CET1 Ratio$_{t-1}$		3.831***				
		(1.000)				
Total Exposure$_{t-2}$ * Tier1 Capital Ratio$_{t-1}$			2.893***			
			(0.870)			
Total Exposure$_{t-2}$ * Total Capital Ratio$_{t-1}$				2.835***		
				(0.925)		
Total Exposure$_{t-2}$ * CET1/Total Assets$_{t-1}$					2.234*	
					(1.237)	
Total Exposure$_{t-2}$ * Equity/Total Assets$_{t-1}$						1.898**
						(0.788)
Total Exposure$_{t-2}$ * Interbank Ratio$_{t-1}$		0.027***	0.025***	0.022**	0.024***	0.025***
		(0.006)	(0.008)	(0.009)	(0.008)	(0.009)
Bank Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country Controls	Yes	Yes	Yes	Yes	Yes	Yes
Other Interactions		Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	1,041	1,041	1,041	1,041	1,041	1,041
No. of Banks	78	78	78	78	78	78
R^2	0.187	0.206	0.204	0.207	0.198	0.199

Notes: This table shows the results for the tests of capital channel and funding channel. Refer to Table 3.5 for full specifications. The coefficient in the first column is estimated from the baseline regression without interaction terms and included in the table as a comparison. From column 2 onward, we start to include interaction terms between exposure and bank strength indicators in to the baseline regressions. As it shows, we test the capital channel with different capital ratios and leverage ratios, and the results are very consistent that the estimated coefficient on the interaction terms are all positive and significant, which provides robust evidence on the capital channel. Besides, the significant estimates on the interaction term between Total Exposure and Interbank Ratio also provide evidence for the funding channel hypothesis.

3.6.4 Capital Channel through Different Types of Exposure

This section decomposes a bank's exposure to the sovereign crisis and interact each exposure term with the bank strength indicators to test the heterogeneity among these different types of exposure in the capital channel. Again, the total exposure is decomposed by its accounting category, residual maturity and counter-party country. The results are present by Table 3.8 - Table 3.10.

Table 3.8 shows the results from the regressions with category breakdown. First column in Table 3.8 shows the baseline result, which suggests that only derivative exposure matters. However, once the interactions between these exposure terms and bank capital dummies are introduced into the regressions, the estimations consistently show that a bank's exposure to the crisis through its AFS sovereign debt holdings has a negative and significant effect on the bank's lending growth rate if the bank is less capitalised. Given the fact that the coefficients on the interaction terms between AFS exposure and bank capital dummies are consistently estimated to be positive and significant across different models, it suggests that higher bank capital would alleviate the adverse effect of bank's exposure to the crisis due to its AFS holdings. Furthermore, it suggests that a bank's AFS sovereign exposure plays a significant role through the capital channel when there is a sovereign shock. This result is consistent with the hypothesis that AFS exposure tend to have a greater effect on less capitalised bank as AFS sovereign debt holdings are not risk-weighted while they are marked-to-market.

Then, it decomposes a bank's exposure to the crisis by the residual maturity, and the results are presented in Table 3.9. The estimations in column 2 and 3 suggests that for less capitalised banks, the short-term exposure tend to have a greater effect on their lending growth. However, this effect is not consistently supported by the regressions with other bank capital dummies. As presented by column 4,5 and 6 in Table 3.9, the interaction term between AFS exposure and total capital ratio, tier 1 capital over total assets, and equity over total assets are all estimated to be insignificant.

Finally, a bank's total exposure to the crisis is decomposed by the counter-party country. Table 3.10 shows the regression results. The baseline results in the first column of Table 3.10 suggests that 1 percent increase in a bank's exposure to the crisis due to its domestic sovereign debt holdings would reduce its lending growth rate by 0.867 percentage points. Result in column 2 suggests that for less capitalised banks the adverse effect would be tripled: 1 percent increase in a bank's domestic exposure would reduce its lending growth rate by 3.17 percentage points if the bank's CET1 ratio is less than 7%. However, the positive and significant estimation on the interaction term suggests that this adverse effect on better capitalised banks would be economically insignificant. This results is confirmed by other regressions with different bank capital indicators.

Table 3.8: Capital Channel through AFS Exposure

Dependent Variable: $\Delta Loan\%$	(1)	(2)	(3)	(4)	(5)	(6)
AFS Exposure$_{t-2}$	-0.297	-8.874*	-10.508**	-4.856	-7.052*	-0.469
	(0.576)	(4.600)	(3.990)	(4.468)	(3.928)	(3.245)
HTM Exposure$_{t-2}$	-0.938	5.431	8.342**	3.538	6.269	0.403
	(0.740)	(5.028)	(4.069)	(5.058)	(4.951)	(4.497)
TB Exposure$_{t-2}$	-0.194	-6.568	-5.420	-6.738	-11.925	-4.346
	(1.160)	(20.491)	(9.199)	(11.203)	(13.463)	(10.003)
Derivative Exposure$_{t-2}$	-13.199**	60.940	58.762	1.418	29.285	32.133
	(6.140)	(42.008)	(44.384)	(47.656)	(51.813)	(43.244)
AFS Exposure$_{t-2}$ * CET1 Ratio$_{t-1}$		6.664**				
		(2.886)				
AFS Exposure$_{t-2}$ * Tier1 Capital Ratio$_{t-1}$			7.752**			
			(3.058)			
AFS Exposure$_{t-2}$ * Total Capital Ratio$_{t-1}$				4.085*		
				(2.174)		
AFS Exposure$_{t-2}$ * CET1/Total Assets$_{t-1}$					8.943**	
					(3.639)	
AFS Exposure$_{t-2}$ * Equity/Total Assets$_{t-1}$						-0.384
						(1.441)
Bank Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country Controls	Yes	Yes	Yes	Yes	Yes	Yes
Other Interactions		Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	1,041	1,041	1,041	1,041	1,041	1,041
No. of Banks	78	78	78	78	78	78
R^2	0.194	0.220	0.222	0.227	0.222	0.218

Notes: This table shows the results from the second-step regressions with category breakdown. Refer to Table 3.5 for full specifications. First column presents the baseline result, which suggests that only derivative exposure matters. However, once we introduce the interactions between these exposure terms with bank capital dummies in to the regressions, the estimations consistently show that a bank's exposure to the crisis through its AFS sovereign debt holdings has a negative and significant effect on the bank's lending growth rate if the bank is less capitalised. It also suggests that higher bank capital would alleviate the adverse effect of bank's exposure to the crisis due to its AFS holdings. Overall it indicates that a bank's AFS sovereign exposure plays a significant role through the capital channel when there is a sovereign shock, which is consistent with the hypothesis that AFS exposure tend to have a greater effect on less capitalised bank as AFS sovereign debt holdings are not risk-weighted while they are marked-to-market.

Table 3.9: Capital Channel through Short-term Exposure

Dependent Variable: $\Delta Loan\%$	(1)	(2)	(3)	(4)	(5)	(6)
Short-term Exposure$_{t-2}$	-0.866	-21.637***	-13.870**	-5.785	-5.544	3.695
	(1.139)	(6.953)	(6.750)	(8.790)	(8.716)	(8.357)
Medium-term Exposure$_{t-2}$	0.507	25.826***	16.004*	9.736	10.727	-7.518
	(1.325)	(7.920)	(8.172)	(9.763)	(10.191)	(10.098)
Long-term Exposure$_{t-2}$	-1.302	-3.781	-2.667	-0.202	-0.706	1.693
	(0.914)	(5.086)	(4.976)	(5.357)	(5.256)	(6.080)
Short-term Exposure$_{t-2}$ * CET1 Ratio$_{t-1}$		16.850***				
		(2.997)				
Short-term Exposure$_{t-2}$ * Tier1 Capital Ratio$_{t-1}$			9.082***			
			(2.393)			
Short-term Exposure$_{t-2}$ * Total Capital Ratio$_{t-1}$				2.178		
				(3.487)		
Short-term Exposure$_{t-2}$ * CET1/Total Assets$_{t-1}$					0.848	
					(5.831)	
Short-term Exposure$_{t-2}$ * Equity/Total Assets$_{t-1}$						-3.915
						(2.804)
Bank Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country Controls	Yes	Yes	Yes	Yes	Yes	Yes
Other Interactions		Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	1,041	1,041	1,041	1,041	1,041	1,041
No. of Banks	78	78	78	78	78	78
R^2	0.190	0.223	0.219	0.221	0.210	0.217

Notes: This table shows the results from the second-step regressions with maturity breakdown. Refer to Table 3.5 for full specifications. First column presents the baseline result for comparison purpose. The estimations in column 2 and 3 suggests that for less capitalised banks, the short-term exposure tend to have a greater effect on their lending growth. However, this effect is not consistently supported by the regressions with other bank capital dummies, as presented from column 4 to column 6.

Table 3.10: Capital Channel through Domestic Exposure

Dependent Variable: $\Delta Loan\%$	(1)	(2)	(3)	(4)	(5)	(6)
Domestic Exposure$_{t-2}$	-0.867**	-3.170**	-3.544**	-1.851	-1.336	-1.182
	(0.433)	(1.470)	(1.348)	(1.532)	(1.521)	(1.695)
Foreign Exposure$_{t-2}$	-0.321	0.647	3.601	3.063	2.459	2.929
	(1.087)	(5.765)	(6.382)	(5.753)	(5.750)	(6.135)
Domestic Exposure$_{t-2}$ * CET1 Ratio$_{t-1}$		4.132***				
		(0.847)				
Domestic Exposure$_{t-2}$ * Tier1 Capital Ratio$_{t-1}$			3.068***			
			(0.850)			
Domestic Exposure$_{t-2}$ * Total Capital Ratio$_{t-1}$				2.810***		
				(0.945)		
Domestic Exposure$_{t-2}$ * CET1/Total Assets$_{t-1}$					2.047*	
					(1.114)	
Domestic Exposure$_{t-2}$ * Equity/Total Assets$_{t-1}$						2.101**
						(0.860)
Bank Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country Controls	Yes	Yes	Yes	Yes	Yes	Yes
Other Interactions		Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,041	1,041	1,041	1,041	1,041	1,041
No. of Banks	78	78	78	78	78	78
R^2	0.189	0.212	0.210	0.212	0.203	0.205

Notes: This table shows the results from the second-step regressions with counterparty country breakdown. Refer to Table 3.5 for full specifications. First column presents the baseline result for comparison purpose. Result in column 2 suggests that for less capitalised banks the adverse effect would be tripled: 1 percent increase in a bank's domestic exposure would reduce its lending growth rate by 3.17 percentage points if the bank's CET1 ratio is less than 7%. However, the positive and significant estimation on the interaction term suggests that this adverse effect on better capitalised banks would be economically insignificant. This results is confirmed by other regressions with different bank capital indicators.

3.6.5 Heterogeneity among GIIPS and Non-GIIPS Banks

As it shows in the previous sections, the results support the hypothetical capital channel through which a bank's sovereign exposure would have a negative effect on the bank's capital given a sovereign shock, which would result in a lower credit supply. On the other hand, this result also suggests that a higher level of bank capital would alleviate the adverse effect caused by a sovereign shock. However, one may argue that for those banks that are located in a crisis country, the adverse effect of the sovereign shock might be too big to be alleviated even if the banks have a higher capital ratio.

This section examines this issue by testing the heterogeneity of the capital effect among GIIPS and Non-GIIPS banks. To do this, a triple interaction term is introduced between $Total\ Exposure$, bank capital indicators and a GIIPS dummy variable in to the regressions. The results are presented in Table 3.11. As it shows, there is no consistently significant estimates on the triple interaction term, which suggests that the there is no significant difference in the effect of capital between GIIPS and non GIIPS banks. Moreover, the estimated coefficient on the triple interaction term is actually positive and significant in column 2, which is evidence that the CET1 capital contributes more on the resilience of the banking system in crisis countries.

Table 3.11: Heterogeneity of Capital Effect among GIIPS and Non-GIIPS Banks

Dependent Variable: $\Delta Loan$	(1)	(2)	(3)	(4)	(5)	(6)
Total Exposure$_{t-2}$	-0.935**	-2.915*	-2.985*	-2.438	-1.076	-0.973
	(0.433)	(1.608)	(1.540)	(1.562)	(1.441)	(1.430)
Total Exposure$_{t-2}$ * GIIPS		-0.669	0.566	0.392	-0.218	0.260
		(0.497)	(0.644)	(0.491)	(0.527)	(0.591)
Total Exposure$_{t-2}$ * CET1$_{t-1}$		3.062***				
		(1.070)				
Total Exposure$_{t-2}$ * CET1$_{t-1}$ * GIIPS		1.858**				
		(0.845)				
Total Exposure$_{t-2}$ * Tier1$_{t-1}$			2.123**			
			(0.979)			
Total Exposure$_{t-2}$ * Tier1$_{t-1}$ * GIIPS			0.872			
			(0.926)			
Total Exposure$_{t-2}$ * Total$_{t-1}$				2.195**		
				(1.031)		
Total Exposure$_{t-2}$ * Total$_{t-1}$ * GIIPS				0.863		
				(1.001)		
Total Exposure$_{t-2}$ * CET1/TA$_{t-1}$					1.049	
					(1.271)	
Total Exposure$_{t-2}$ * CET1/TA$_{t-1}$ * GIIPS					2.070**	
					(0.802)	
Total Exposure$_{t-2}$ * Equity/TA$_{t-1}$						0.740
						(0.949)
Total Exposure$_{t-2}$ * Equity/TA$_{t-1}$ * GIIPS						2.567***
						(0.960)
Bank Controls	Yes	Yes	Yes	Yes	Yes	Yes
Country Controls	Yes	Yes	Yes	Yes	Yes	Yes
Other Interactions		Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
No. of Observations	1,041	1,041	1,041	1,041	1,041	1,041
No. of Banks	78	78	78	78	78	78
R^2	0.187	0.208	0.208	0.209	0.202	0.210

Notes: This table shows the results from the regressions with a a triple interaction term between *Total Exposure*, bank capital indicators and a GIIPS dummy variable, by which we explosre the heterogeneity of the capital effect among GIIPS and Non-GIIPS banks. The sample contains 34 GIIPS banks and 44 non-GIIPS banks. Refer to Table 3.5 for full specifications. First column presents the baseline result for comparison purpose. It shows that the triple interaction term are not consistently estimated to be significant, which suggests that the there is no significant difference in the effect of capital between GIIPS and non GIIPS banks. Moreover, the estimated coefficient on the triple interaction term is actually positive and significant in column 2, which is evidence that the CET1 capital contributes more on the resilience of the banking system in crisis countries.

3.7 Conclusion

The Euro Area sovereign debt crisis showed how banks' large exposures to distressed governments could lead to instability in the banking system. Large exposures can give rise to a 'doom loop' between governments and the banking system, impairing banks' solvency and credit supply as a result. This causes slower economic growth, which in turns increases further the sovereign's distress. This was indeed the case for the Euro Area sovereign debt crisis. The impact of Euro Area sovereign distress on the banking system may have been more pronounced because the regulatory requirements on banks' sovereign exposures are very low. For example, banks are not required to have any capital against the credit risk they face with their exposures to EU sovereigns irrespective of the risk those sovereigns may default. Regulatory limits on large exposures also exempt exposures to sovereigns. And until 2017, banks were not required to deduct fully from regulatory capital the losses incurred on sovereign exposures held as available for sale.

The links between sovereign exposures and bank lending have been explored in a number of papers, but none of them have focused on the different accounting treatment that these exposures can have. These differences might have important implications, not only to understand the transmission channels from sovereign shocks to bank lending, but also for the design of new regulation. And this is precisely what this essay aims to do: it investigate whether the accounting treatments of sovereign exposures affected the strength of transmission of the Euro Area sovereign debt crisis onto banks and bank lending. One of the key differences in accounting treatment is the approach to valuing an exposure. Some exposures are valued according to their value when they were created ('historical cost' basis), while others are valued according to their current market value ('fair value' basis). Some have put forward theories for why fair value accounting can increase instability in the banking system.

This chapter sheds light on the main channels through which shocks to the value of sovereign bonds may affect bank lending behaviour and whether capital could alleviate the transmission mechanism. It uses the European Banking Authority (EBA) stress tests and transparency exercises, which contain granular information of banks sovereign exposures, in order to focus on the accounting definition of these exposures, since some exposures are recorded mark-to-market while others at book valuation. This allows the analysis to have a much more precise estimate of how exposed to the sovereign debt turmoil banks are. These data are matched with bank-level balance sheet information obtained from SNL, such as solvency ratios, asset size, or position in the interbank market, from 2010 to 2016.

In line with previous studies, the findings suggest that negative shocks to sovereign bond prices are associated to lower subsequent bank lending for banks more exposed to the shocks, but these relation is weaker for better capitalised banks (Kirschenmann et al., 2016), what is known as the 'capital channel'. Moreover, it shows that bank capital matters especially for exposures that are both mark-to-market and subject to no capital requirements, such as available for sale (AFS) exposures: this seems to be the type of exposure through which sovereign shocks are transmitted directly to bank solvency. The capital channel is less important for book-value exposures (held to maturity (HTM)) and exposures with positive capital requirements (held for trading (HFT)). It also reveals that the capital channel is particularly important for short-term exposures (rather than medium- and long-term) and domestic exposures (rather than foreign). These results provide useful evidence to design a more robust regulatory capital framework for sovereign exposures.

Chapter 4

BANKING COMPETITION AND FINANCIAL STABILITY: Evidence from the U.S. Banking Deregulation

4.1 Introduction

Following Keeley (1990)'s research, there has been a ongoing debate on the relationship between bank competition and financial stability in the literature for more than two decades. This issue became especially important after the 2008 global financial crisis, which has been widely attributed to the intensified competition in the financial sector due to the U.S. banking deregulation and also the worldwide financial liberalisation. As a result, the crisis induced large cost for the government and in turn for the general public, and finally evolved into a long-lasting economic recession in many major economies. On one hand, higher competition is generally desirable as it is positively associated with economic efficiency in theoretical models. Thus insufficient competition means lack of efficiency which would harm the overall social welfare. On the other hand, financial crises that might be caused by the intensive competition in the financial sector is costly for everyone in the economy. Therefore, it is essential to understand the relationship between banking competition and banking stability for policy makers to balance their goals: maintaining financial stability while facilitating competition in the financial sector.

Taking the recent crisis as a example, many argue that the banking deregulation and financial liberalisation in the past decades intensified the overall level of competition in the financial sector, which then encouraged bank and other types of financial institutions (investment banks mainly) to take excessive risks to compete for profit. This argument is in line with the competition-fragility hypothesis. It argues that in a more competitive environment banks would lose their "charter value" thus are more likely to shift risk towards depositors with the deposit insurance policy, while in a less competitive environment banks tend to have higher profit and also more capital buffer, thus are not likely to take excessive risks which could endanger the whole financial system (Keeley, 1990; Beck et al., 2006; Berger et al., 2009; Beck et al., 2013).

However, the competition-stability hypothesis argues that there is a positive relationship between bank competition and financial stability, rather than a trade-off. Lower lending rates resulted from higher level of bank competition reduces borrowing cost for both firms and individuals, and this in turn would reduce banks credit risk. Thus, the banking system as a whole would be more stable in a competitive environment (Schaeck et al., 2009; Anginer et al., 2014). In addition, it is also possible that there is an U-shaped relationship between competition and stability. For a less competitive banking system, more competition would be preferred due to increased efficiency and stability, but if the system is already highly competitive, further increase in competition might induce excessive risk taking which threatens the stability of the system. Therefore the effect of competition on stability could go either way depending on where the banking system is located on the U-shaped curve (Martinez-Miera and Repullo, 2010; Hakenes and Schnabel, 2011). Overall, both theoretical models and empirical evidence provide mixed results.

The aim of this study is to identify the effect of banking competition on banking stability with a robust empirical setting. The U.S. bank branching deregulation in the 1980s provides an opportunity to implement the difference-in-difference (DID) method to identify the causal relationship between the competition shock on banking stability. The U.S. banking system has a long history of regulation while the deregulation is just a recent story. Most of the states in the U.S. did not allow banks to branch across counties or states before the 1980s. In the late 1970s, the ability of banks to compete over a longer distance was enhanced by some technological improvements, such as the invention of ATM. As a result, individual states started to deregulated their banking system both intra-state and inter-state branching, which resulted in a higher level of competition in the banking sector. A very important feature of the deregulation is that different states deregulated their banking system at different point in time. Taking advantage of this feature, the DID method is easily implemented to address the causality issue. In addition, dynamic DID method also implemented as a robustness check.

Following Beck et al. (2013), the banking stability is measured by Z-score calculated with a 3-year rolling window. Furthermore, alternative indicators for banking stability are also adopted in the analysis, such as the inverse standard deviation of ROA and non-performing loan ratio. All these indicators are calculated at both state-level and bank-level.

The analysis shows that the intensified competition shock caused by the intra-state branching deregulation significantly improves the state-level banking stability by 45.2%. The result is not only statistically but also economically significant. Meanwhile, it shows that the inter-state branching deregulation is estimated to have no significant impact on banking stability at state-level. This baseline result is confirmed by the dynamic difference-in-difference regressions and also the regressions with alternative stability indicators. The bank-level analysis shows consistent result that the intra-state competition shock has a positive and significant effect on the stability of individual banks, which is also robust with the dynamic DID setting and alternative bank-level stability indicators. However, the scale of the estimated effect at bank-level is much smaller: the intensified intra-state competition just improves the stability of individual banks by 2.12% on average. Overall, these findings provide both state-level and bank-level evidence on the competition-stability hypothesis that banking competition improves banking stability.

As the sample period of this analysis covers almost 20 years, there are some banks entering and exiting the sample. The unbalanced feature of the bank-level panel dataset may bias the estimated effect of the competition shock on bank-level stability. To examine this issue, both typical DID and dynamic DID regressions are implemented with a balanced bank-level panel dataset as robustness checks. The results from these regressions are qualitatively unchanged compared with the previous findings from the bank-level analysis. Furthermore, it examines the heterogeneity among banks from three perspectives: bank size, bank profitability and the competition environment faced by the bank. It shows that the intra-state competition shock has a greater effect on the stability of small banks, while big banks and more profitable banks are more likely to be affect by the inter-state competition shock. The heterogeneity test also shows that the stability of banks operating in a less competitive environment are more likely to be improved by the inter-state competition shock, which provides evidence on the non-linear relationship between banking competition and stability.

The rest of this chapter proceeds as follow. Section 4.2 reviews the literature in relation with this study. Section 4.3 explains the empirical setting and model specifications for the econometric analysis. Section 4.4 describes the main database and variables. Section 4.5 presents the main results from the analysis and provides discussions before Section 4.6 concludes.

4.2 Literature Review

This study is related to 2 strands of literature. Primarily, it is directly related to the papers which identifies the effect of bank competition on financial stability. Literature on this topic has been comprehensively reviewed by Carletti and Hartmann (2002), Beck (2008) and Vives (2011). However, none of them conclude that there is an unambiguous relationship between competition and stability.

A pioneering research is done by Keeley (1990) who develops a theoretical model suggesting that with protection of the deposit insurance, bank's moral hazard problem would be intensified due to increased competition and decreased charter value. Keeley (1990) also provides empirical evidence by using U.S. banking deregulation in the 1980s as a test for the effect of increased competition. The results show that higher level of competition in the banking system would increase bank's default risk by increase in assets risk and decrease in bank capital. Allen and Gale (2004) provides a purely theoretical analysis on the effect of competition on financial stability. They use different types of models to address this question: general equilibrium models of financial intermediation and markets, agency models, spatial competition models, Schumpeterian competition models, and contagion models. However, the predictions of these models are not consistent. In some cases competition are positively related with stability while other models predict a trade-off between competition and stability.

Theoretically, higher level of competition reduce bank's charter value thus they tend to take excessive risks, while another possibility is that intensive competition in banking system reduce borrowing cost thus banks would face less credit risks. However, Martinez-Miera and Repullo (2010) argues that there is another channel: higher competition not only reduce bank's credit risks but also reduce their profit from performing loans, which provides provisions for loan losses. Taking this into account, Martinez-Miera and Repullo (2010)'s model predicts an U-shaped relationship between competition and stability. Competition affects bank stability through 2 channels: 1)*risk-shifting effect* by which higher loan rate due to lack of competition would increase credit risks faced by banks; and 2)*margin effect* through which bank's revenue would be reduced since higher competition would reduce bank's interest margin. They found that in a highly competitive banking system, margin effect is dominant thus further increase in the level of competition would have a negative effect on bank stability, while risk-shifting effect is dominant in a concentrated system therefore more competition is helpful for bank stability. Hakenes and Schnabel (2011) also proposed a model suggesting that there is a U-shaped relationship between competition and stability, thus the effect of capital requirement on financial stability would be ambiguous due to the non-linear effect of bank competition.

In terms of empirical literature, there is also no consensus among the relationship between bank competition and financial stability. Using data for 69 countries from 1980 to 1997, Beck et al. (2006) shows that banking crisis is less likely to occur in countries where the banking system is highly concentrated, where the bank concentration is measured by the proportion of total assets held by the largest banks in the system. However there is a doubt whether bank concentration is a good indicator for the level of bank competition. Measuring competition by Panzar and Rosse H-statistics for 45 countries, Schaeck et al. (2009) show that highly competitive banking system are less likely to suffer from systemic banking crisis, even when bank concentration is controlled in the model. This result suggests that bank concentration and competition captures different aspect of a banking system thus concentration may not be an accurate indicator for competition.

Using bank-level data, Berger et al. (2009) calculate a variety of measurement for bank market power and stability at individual bank level. Overall, their results are consistent with the competition-fragility hypothesis that banks with higher market power generally have less risks. Though they also found that bank's portfolio risks would increase due to higher market power, it argues that this risk may partly offset by higher bank capital. Beck et al. (2013) also uses bank level data to investigate the effect of bank's market power on bank soundness, where market power is measured by Lerner index and soundness is measured by Z-score. The results show that there is a consistent positive relationship between bank's markets power and soundness, indicating that higher level of competition would erode bank's charter value then increase bank's risk taking incentives. These results are consistent with Berger et al. (2009). In addition, their study shows that the positive relationship between market power and stability is even more significant in countries where there are stricter activity restrictions, lower systemic fragility, better developed stock markets, more generous deposit insurance and more effective credit information sharing system.

Anginer et al. (2014) also use bank-level data to calculate market power and risk measurement. Similar with Beck et al. (2013), the market power is measured by bank's Lerner index. However, they use bank's Distance to Default (DD) as a measurement for bank risk, which is initially proposed by Merton (1974). There are two advantages using this indicator rather than Z-score: first, both Lerner index and Z-score are calculated based on profitability measures, which makes them more likely to be positively correlated, thus using DD indicator avoids this potential problem; second, Z-score is calculated from bank's balance sheet (usually annual data) while DD indicator is based on market value (daily basis), which makes DD measurement updated more frequently and also more forward looking. Overall, their results suggest that bank competition have a positive effect on bank stability, and this effect is quite robust. This result is in line with the competition-stability hypothesis.

Apart from the literature on the topic of competition and stability, this study is also related with papers identifying the effect of the U.S. banking deregulation. Most papers in this area focus on the real effect of the deregulation. Strahan (2003) is the first one using the U.S. banking deregulation as an empirical experiment to test its real effects on three aspects: growth, entrepreneurship, and business cycle. It shows that the growth rate of state income in real per capita significantly increased after banking deregulation, which is consistent with Schumpterian view on the effect of financial development on economic growth. It also shows that the number of newly established incorporation is significantly higher in the post-deregulation period, suggesting that banking deregulation also have a positive effect on entrepreneurship. Finally it also suggests that the overall state-level business cycle is significantly mitigated after inter-state banking deregulation due to financial integration among states.

Subsequent literature test the real effect of U.S. banking deregulation on many other different aspects, using the method proposed by Strahan (2003). For example, Rice and Strahan (2010) whether finance for small firms could be affected by banking deregulation. Overall it shows that interstate-branching deregulation has a positive effect on small firm finance: the borrowing cost for small firms are significantly lower in open states. Landier et al. (2013) examine the effect of interstate banking deregulation on housing price co-movement. It suggest that financial integration due to interstate banking deregulation explains 25% of the increased housing price correlations over the 1976-2006 period. Kneer (2013) focuses on the labour market. It shows that interstate banking deregulation significantly reduces labour productivity in skill-intensive industries, as many skilled labour were absorbed by the banking industry after the deregulation. Beck et al. (2010) shows that the income of low-income group are significantly increased after deregulation while the effect on high-income group are not significant, thus banking deregulation tightens the income distribution. All these paper are related with my study in terms of methodology.

A few papers also use the U.S. banking deregulation as a experiment to identify the effect of bank competition on bank performance or stability. Stiroh and Strahan (2003) and Strahan (2003) find that banks with better performance would tend to grow faster in terms of bank size after banking deregulation, indicating that banking assets are reallocated towards better banks due to the effect of increased competition. However, their studies has little implication on financial stability in post-deregulation period. Using similar method, Subramanian and Yadav (2012) show that the instance of bank failure significantly reduced after banking deregulation, arguing that there is a increase in banking stability as a results of banking deregulation. Nonetheless, bank failure might not be seen as a stability indicator. The reduction in the number of bank failures could be attribute to the deregulation policy which allows bank to carry out merge and acquisition, which does not necessarily mean that there is a overall improvement in banking stability. Thus, my study is going to fill this gap in the literature by testing the effect of bank competition on financial stability with a variety of stability measurements at both state-level and bank-level, using the U.S. banking deregulation as a natural experiment.

Overall, the contribution of this paper is twofold. First, using the intensified competition in the banking sector caused by the US banking deregulation as an exogenous shock, this paper identifies the relationship between bank competition and stability with a Difference-in-Difference method, instead of the method of GMM exploited by most of the empirical papers in the existing literature. Second, it provides empirical evidence on the non-linear relationship between bank competition and stability derived from the recent theoretical works (Martinez-Miera and Repullo, 2010; Hakenes and Schnabel, 2011) which has not been investigated empirically.

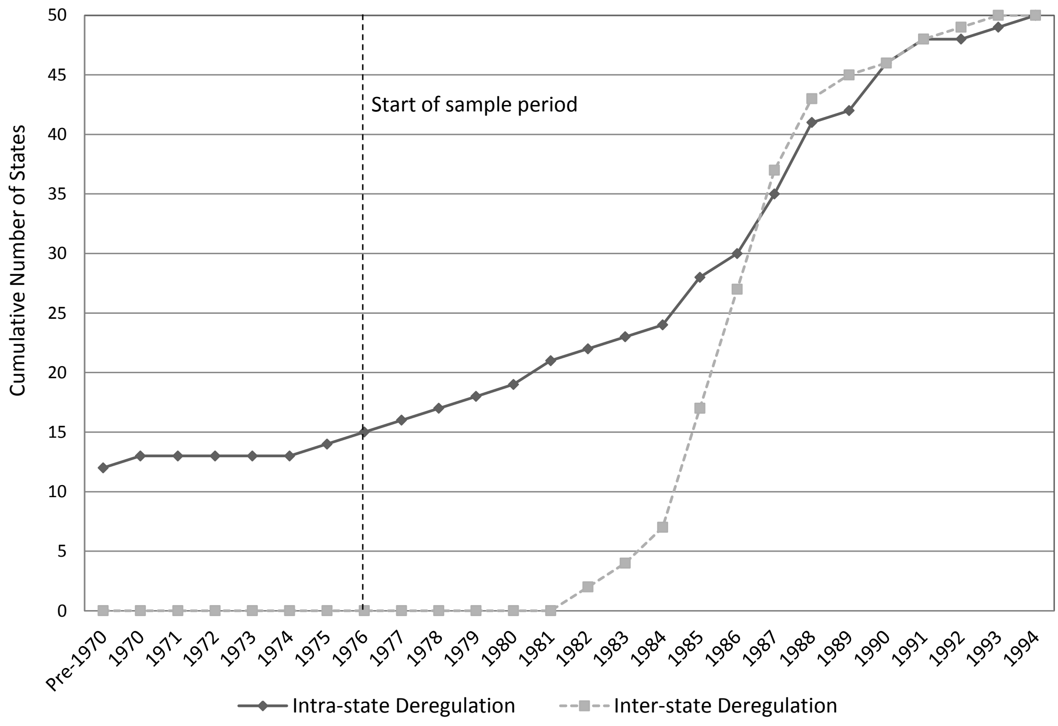
4.3 Empirical Setting

4.3.1 The U.S. Banking Deregulation

The U.S. banking system has a long history of regulation while deregulation is only a recent story. Branch banking across counties or states was not allowed until 1980s. Thus, the banking system of the U.S. had a unitary structure where most entities in the system were stand-alone banks. Since the late 1970s, individual states in the U.S. started to deregulate their banking system for both intra-state and inter-state branching which allowed banks to branch across counties and states respectively. One of the reasons of the deregulation is that the ability of banks to compete over a longer distance was enhanced by the technological improvement (e.g. the invention of ATM). The deregulation in branch-banking resulted in an intensified competition in the banking sector as it broke the policy barrier of market entry thus exposed less efficient incumbent banks in a certain county or state to the more efficient competitors from other administrative regions.

There were two types of bank branching deregulation ongoing: intra-state branching and inter-state branching. Intra-state branching deregulation was to allow banks to branch across counties within a state while Inter-state branching deregulation was to allow banks to branch across different states. Apart from this, another major difference between the two types of deregulation is that Intra-state branching deregulation was implemented with immediate effect while it could take a long time for Inter-state branching to be effective as it was based on state-level reciprocations. For example, Alabama deregulated their banks for inter-state branching in 1987. However, the banking sector of Alabama would still be a closed system and would not be exposed to outside competitors until another state reach an agreement with Alabama on the issue of interstate bank branching. Therefore, one may expect that the competition level of the banking sector would not be intensified immediately after the implementation of the Inter-state deregulation.

Figure 4.1: Cumulative Number of Deregulated States

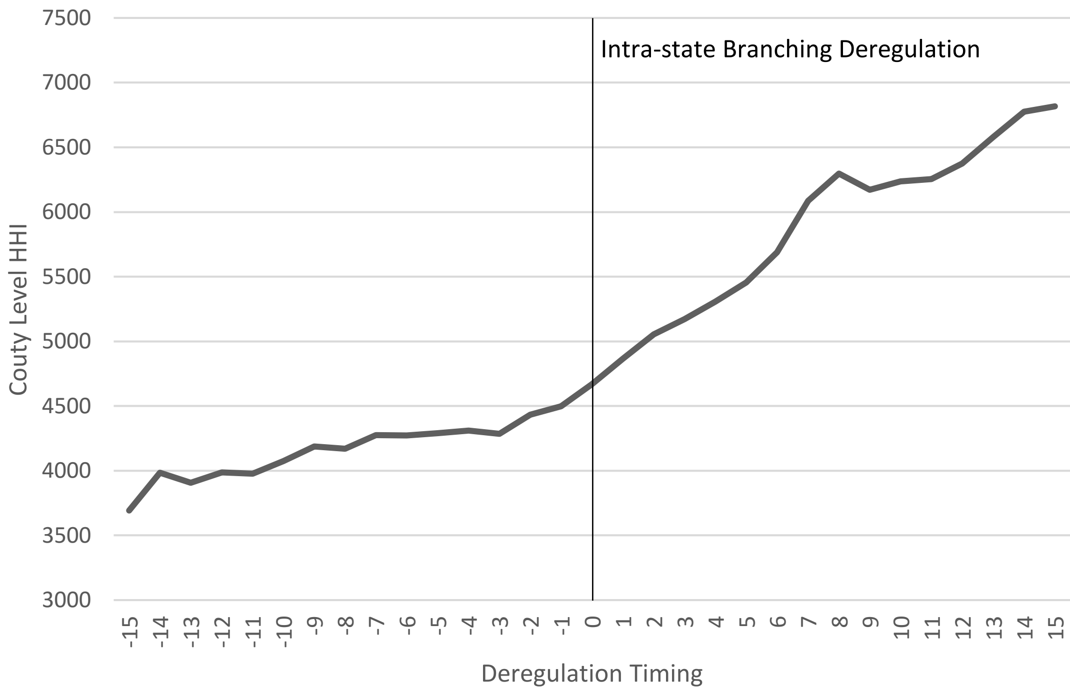


Source: Amel (1993) and Jayaratne and Strahan (1996)
Notes: This figure shows the number of states where intra- or inter-state bank branching is deregulated over the period of 1970 - 1994.

Figure 4.1 shows the number of states where intra- or inter-state bank branching is deregulated over the period of 1970 - 1994.[1] As it shows, both types of deregulation were levied individually by each states. This staggered feature of the U.S. banking deregulation provides us an opportunity to test the effect of the intensified competition in the banking sector due to the deregulation policies on the stability of the banking sector with the Difference-in-Difference method.

[1]See Table A4.1 in the appendix for detailed timing of both intra- and inter- state deregulation in each state. For example, the intra-state branch banking was not regulated before 1970s in California while the inter-state branch banking in California were deregulated in 1987.

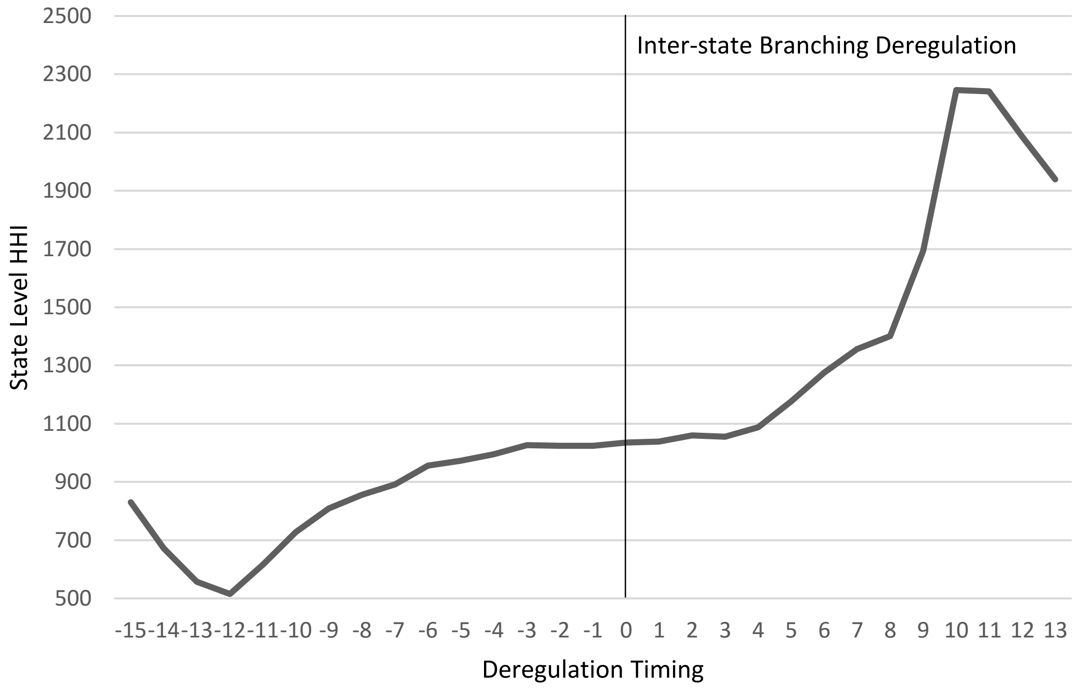
Figure 4.2: Trend of County-level HHI



Notes: This figure shows the average trend of county-level HHI in the banking sector across the U.S.. Sample period: 1976 - 1994. The horizontal axis depicts the years around the year of intra-state deregulation.

Figure 4.2 illustrates the average trend of county-level Herfindahl-Hirschman Index (HHI) for the banking sector across the U.S. before and after the intra-state branching deregulation, where the data were collected for the period from 1976 to 1994. The horizontal axis depicts the years around the year of intra-state deregulation. As it shows, the increasing trend of county-level HHI is relatively flat before the intra-state branching was deregulated, while the average trend becomes much steeper after the intra-state deregulation. It indicates that the banking market become more concentrated at the county level after the deregulation, as the banking integration had been accelerated by the deregulation which allows for cross-county mergers and acquisitions.However, it does not mean that the banking sector become less competitive as the HHI increased after the deregulation. On the contrary, the intra-state deregulation intensifies the competition level in the banking sector as it exposed local banks to a larger market, so that the post-deregulation competition level should be indicated by the HHI calculated at the state-level.

Figure 4.3: Trend of State-level HHI



Source: Amel (1993) and Jayaratne and Strahan (1996)
Notes: This figure shows the number of states where intra- or inter-state bank branching is deregulated over the period of 1970 - 1994.

Similarly, the average trend of state-level HHI for the banking sector across the U.S. has been depicted around the timing of the inter-state branching deregulation in Figure 4.3, based on a sample period from 1976 to 1994. Overall, it suggests that the banking sector in the U.S. became more concentrated at the state-level after the introduction of the inter-state branching deregulation, as the average trend before the deregulation is relatively flat while the trend is more upward-sloping after the deregulation year. However, as the figure shows, the effect of the inter-state deregulation on the state-level market structure is lagged by 4-5 years on average. This is lagged effect might be due to the fact that the inter-state branching deregulation is based on a state-level reciprocation, so that it takes time for the deregulation to take effect on the banking sector.

4.3.2 Measurement for Competition and Stability

The aim of this study is to test the causality between bank competition and bank stability, thus the measurement of competition and stability is the key issue throughout the analysis. Most empirical papers in the competition-stability literature use different types of synthetic competition indicators such as market concentration (Beck et al., 2006), H-statistics (Schaeck et al., 2009) or Learner index as a measurement of market power (Berger et al., 2009; Beck et al., 2013; Anginer et al., 2014).

Different from those papers, this study looks at the exogenous competition shocks caused by the banking deregulation in the U.S. during the 1980s, as the policy changes exposed the local banking system to outside competitors. Therefore, two dummy variables - $Intra$ and $Inter$ - are created as the equations show below in order to capture the competition shocks caused by the intra-state and inter-state deregulation.

$$Intra_{s,t} = \begin{cases} 1, & \text{if intra-state branching is deregulated;} \\ 0, & \text{otherwise.} \end{cases}$$

$$Inter_{s,t} = \begin{cases} 1, & \text{if inter-state branching is deregulated;} \\ 0, & \text{otherwise.} \end{cases}$$

where s stands for each state and t stands for each year. As the equations show, the dummy variable $Intra$ would be equal to 1 if the intra-state branching has been deregulated in state s at time t, otherwise it would be equal to 0. Similarly, the dummy variable $Inter$ would be equal to 1 if the inter-state branching has been deregulated in state s at time t, otherwise 0.

The dummy variables based on the timing of the two types of banking deregulation capture the exogenous competition shock to the banking system induced by the policy changes in different states at different time period. Then, the causal relationship between bank competition and stability can be identified by the effect of the competition shock on the stability of the banking system.

From the econometric perspective, the two deregulation dummy variables can be seen as the Difference-in-Differences (DID) term in a regression. Banks/states with deregulation dummy variables equal to 1 can be seen as the treatment group in a Difference-in-Differences setting while those with deregulation dummy variables equal to 0 the control group. For example, Alabama deregulated intra-state bank branching in 1981 but its neighbour state Mississippi implemented the same policy not until 1986. In this case, the effect of the competition shock due to the policy change (treatment effect) on the banking system can be correctly identified by comparing the banking system in the two states during the period 1981-1985, meanwhile considering their difference before 1981 and after 1986 (common trend).

Apart from the indicator for bank competition, the measurement on bank stability is also important. Following Beck et al. (2013), we use the Z score as the main indicator for bank stability in this study. The Z score at bank-level is calculated as the equation shows below:

$$Z\ Score_{i,s,t} = \frac{ROA_{i,s,t} + Equity_{i,s,t}/Asset_{i,s,t}}{\sigma_n(ROA_{i,s})} \tag{4.1}$$

where i stands for each bank, s stands for each state and t stands for each year. The denominator of the fraction, $\sigma_n(ROA_{i,s})$, is the standard deviation of the return on assets for bank i in state s with a time rolling window of n. As frequently used in the literature of financial economics as a risk indicator, the standard deviation of return captures the risk of a bank in a given period around time t. The numerator of the Z score has two components: the return on assets of bank i at time t and the bank's equity over assets. The summation of the two components can be seen as a measurement for a bank's solvency at a point in time. Thus, the Z score as a whole captures a bank's solvency per unit of its risk. Higher Z score indicates better stability.

Similarly, using aggregate data at state-level, the state-level Z score is calculated based on the following equation:

$$Z\ Score_{s,t} \ = \ \frac{ROA_{s,t} + Equity_{s,t}/Asset_{s,t}}{\sigma_n(ROA_s)}. \tag{4.2}$$

4.3.3 Regression Specifications

The U.S. banking deregulation during the 1980s is exploited as a natural experiment to test the effect of the exogenous competition shock on individual bank risks and also the financial stability in each state. As explained in the previous section, the staggered feature of the policy changes allows us to use Difference-in-Difference(DID) method to examine the effect of the increased competition due to the deregulation policy.

Following Strahan (2003), the specifications of the regression model are illustrated by the equations below, where equation (1) shows the model for state-level analysis and equation (2) shows the bank-level analysis. Both intrastate and interstate banking deregulation are of interest, thus the DID method is implemented by the dummy variables for intra- and inter-state banking deregulation in the models.

$$Stability_{s,t} = \alpha_0 + \alpha_1 Intra_{s,t} + \alpha_2 Inter_{s,t} + \alpha_4 X_{s,t} + \gamma_t + \gamma_s + \epsilon_{s,t} \tag{4.3}$$

$$Stability_{i,s,t} = \alpha_0 + \alpha_1 Intra_{s,t} + \alpha_2 Inter_{s,t} + \alpha_3 X_{i,s,t} + \alpha_4 X_{s,t} + \gamma_t + \gamma_s + \epsilon_{i,s,t} \quad (4.4)$$

where

- i stands for each bank in the sample
- s stands for each state in the sample
- t denotes each quarter/year over the sample period
- $Stability_{s,t}$ is the state-level stability measurement for state s at time t
- $Stability_{i,s,t}$ is the bank-level stability measurement for bank i in state s at time t
- $Intra_{s,t}$ is a dummy variable for intrastate branching deregulation which takes value 1 if the time is after the deregulation year; otherwise 0
- $Inter_{s,t}$ is a dummy variable for interstate banking deregulation which takes value 1 if the time is after the deregulation year; otherwise 0
- $X_{i,s,t}$ is a set of bank-level control variables for bank i in state s at time t
- $X_{s,t}$ is a set of state-level control variables for state s at time t
- γ_t is time dummy variables controlling for year effect
- γ_s controls for state level fixed effect for state s
- $\epsilon_{i,s,t}$ is the error term for bank i in state s at time t

The key parameters to be estimated is the coefficient on the dummy variables for both intra- and inter-state banking deregulation, as measurement for competition shocks in the banking system. A positive and significant coefficient on the dummy variables would indicate that competition has a negative effect on banking stability and vice versa. If the coefficient is not significant at all, it might imply that there is a non-linear effect of competition on stability.

Dynamic Difference-in-Difference method is also implemented at both state- and bank-level with the regression specification illustrated by equation (3) and (4) respectively:

$$Stability_{s,t} = \alpha_0 + \alpha_1 Dereg3\_1_{s,t} + \alpha_2 Dereg0\_2_{s,t} + \alpha_3 Dereg3\_5_{s,t} + \alpha_4 Dereg6\_\ _{s,t} + \alpha_5 X_{s,t} + \gamma_t + \gamma_s + \epsilon_{s,t} \quad (4.5)$$

$$Stability_{i,s,t} = \alpha_0 + \alpha_1 Dereg3\_1_{s,t} + \alpha_2 Dereg0\_2_{s,t} + \alpha_3 Dereg3\_5_{s,t} + \alpha_4 Dereg6\_\ _{s,t} + \alpha_5 X_{i,s,t} + \alpha_6 X_{s,t} + \gamma_t + \gamma_i + \epsilon_{i,s,t} \quad (4.6)$$

where

- $Dereg = \{Intra, Inter\}$;
- $Dereg3\_1_{s,t}$ is a dummy variable equal to 1 if time t is 3, 2 or 1 year before the deregulation in state s; otherwise 0;
- $Dereg0\_2_{s,t}$ is a dummy variable equal to 1 if time t is the deregulation year in state s, or 1 and 2 year after the deregulation; otherwise 0;
- $Dereg3\_5_{s,t}$ is a dummy variable equal to 1 if time t is 3, 4 or 5 year after the deregulation in state s; otherwise 0;
- $Dereg3\_5_{s,t}$ is a dummy variable equal to 1 if time t is 6 year or more after the deregulation in state s; otherwise 0.

Different from a general set-up of a DID model, there are two treatments in this analysis: the competition shock induced by the intra-state deregulation and the shock induced by the inter-state deregulation. However, the timing of the two types of deregulation for the same state might be correlated to some extent, so that including the two treatment in a single regression at the same time might increase the standard error estimated on the DID terms, which would result in lower significance levels for the treatment effect. To clearly identify the treatment effect, the DID dummy variables for the two types of deregulation are first included in the regression one by one separately, then included into a single regression together. By comparing the size and significance of the estimated coefficient on the DID terms across different models, one can be sure that whether the potential correlation between the two types of deregulation can bias the estimations.

4.4 Data

The main database for this study is *Consolidated Reports on Condition and Income* (Call report). It provides detailed balance sheet and income statement data for all banking institutions regulated by the *Federal Deposit Insurance Company* (FDIC). The sample period is from 1976 to 1994, with an annual frequency for 19 periods. The final sample in this analysis includes 250,654 observations for 18,012 banks from 49 states.

Summary statistics for both state-level and bank-level analysis are presented by Panel 1 and Panel 2 in Table 4.1 respectively. The top part of each panel lists the all the banking stability indicators used in the following analysis, while the rest of each panel lists all the control variables.

The first variable in the list, $log(Z_3)$, is the logarithm of Z score calculated with a 3-year rolling window, which is the main stability indicator throughout the analyses at both state-level and bank-level. In addition, Z score with a 5-year rolling window, inverse standard deviation of ROA with 3- and 5-year rolling window, and the Non-performing loan ratio are also used as alternative indicators for banking stability. It shows that the non-performing loans at state-level account for 2.37 percent of total loans on average over the period from 1983 to 1994.[2]

Size is the logarithm of total banking assets in a state. It controls for the effect of the size of the banking sector on banking stability. *Size Growth* is the year-on-year growth of the total banking assets in a state. One might expect a negative relationship between growth and stability as those who expand faster tend to take more risks on board. The variable commercial and industrial loans over total loans (*C&I loans*) controls for the riskiness of the loan portfolio of a bank/banking sector, as lending to commercial and industrial sectors tend to be riskier than mortgages

[2]Though the main sample period starts from 1976, the data on non-performing loans are only available from 1983 onward.

Table 4.1: Summary Statistics

	Mean	St.D.	Min	Max	Obs.
Panel 1: State-level Analysis					
Stability Indicators					
$log(Z_3)$	4.34	1.12	0.03	7.25	833
$log(Z_5)$	3.94	1.02	0.17	6.70	735
$log(1/\sigma_3(ROA))$	2.45	0.94	0.41	5.23	833
$log(1/\sigma_5(ROA))$	2.10	0.81	0.45	4.57	735
NPL Ratio	2.37	1.57	0.38	12.77	588
Banking Sector Controls					
Size	17.00	1.19	14.28	20.59	931
Size Growth	0.44	0.41	-2.43	3.24	882
C&I Loan	27.48	7.34	5.42	53.25	931
Loan to Assets	58.29	7.33	30.41	80.41	931
Liquidity	26.94	7.90	4.32	48.18	931
Interbank Borrowing	6.68	3.43	0.42	30.81	931
Macroeconomic Controls					
GDP Growth	3.37	4.20	-28.08	30.61	931
Unemployment	6.69	2.09	2.30	17.80	931
Housing Price Index	4.79	0.33	3.95	5.76	931
Panel 2: Bank-level Analysis					
Stability Indicators					
Log(Z-score3)	4.23	0.71	0.81	10.54	213,323
Log(Z-score5)	3.60	0.79	-1.27	8.06	180,458
Log(1/sigma(ROA)3)	1.77	0.82	0.00	8.01	213,326
Log(1/sigma(ROA)5)	1.51	0.65	0.01	6.34	180,464
Non-performing Loan	2.22	2.91	0.00	100.00	148,636
Bank Level Controls					
Size	10.54	1.27	5.46	19.16	246,201
Size Growth	0.91	1.69	-43.12	84.22	229,760
C&I Loan/Total Loan	20.96	13.93	0.00	100.00	245,871
Loan/Total Asset	53.69	14.04	0.00	100.00	246,071
Liquidity	34.51	14.77	0.00	99.94	246,200
Interbank Borrowing	1.30	3.70	0.00	92.52	246,200
State Level Controls					
GDP Growth	3.01	3.75	-28.08	30.61	246,213
Unemployment	6.68	2.06	2.30	17.80	246,213
Housing Price Index	4.74	0.28	3.95	5.76	246,213

Notes: $log(Z_3)$ is the logarithm of Z score calculated with a 3-year rolling window, which is the main stability indicator in both state- and bank-level analysis. In addition, Z score with a 5-year rolling window ($log(Z_5)$), inverse standard deviation of ROA with 3- and 5-year rolling window ($log(1/\sigma_3(ROA)), log(1/\sigma_5(ROA))$), and the Non-performing loan (NPL) ratio are also used as alternative indicators for banking stability. *Size* is the logarithm of total banking assets in a state. *Size Growth* is the year-on-year growth of the total banking assets in a state. The variable *C&I loans* is commercial and industrial loans over total loans, which controls for the riskiness of the loan portfolio of a bank/banking sector. *Loan to Assets* ratio controls for the overall riskiness of the total assets of a bank/banking sector. *Liquidity* is defined by total liquid assets over total assets, which captures the capability of a bank/banking sector to meet its short-term obligations. *Interbank Borrowing* captures the interconnectness of the banking sector, or a bank's dependence on unstable short-term funding. Finally, state-level *GDP Growth* rate, *Unemployment* rate, and *Housing Price Index* are used to control for the influence of macroeconomic conditions on banking stability.

and other types of lending. Compared with central bank reserves, investment in government bonds and other types of investment, loans are the riskiest assets on a bank's balance sheet. Thus, *Loan to Assets* ratio controls for the overall riskiness of the total assets of a bank/banking sector. *Liquidity* is defined by total liquid assets over total assets, which captures the capability of a bank/banking sector to meet its short-term obligations. *Interbank Borrowing* captures the interconnectness of the banking sector, or a bank's dependence on unstable short-term funding. Finally, state-level *GDP Growth* rate, *Unemployment* rate, and *Housing Price Index* are used to control for the influence of macroeconomic conditions on banking stability.

4.4.1 Mean Test at State-level

The analysis proceeds with a simple mean test at state-level, to identify the difference in banking stability and other banking sector characteristics before and after the two types of banking deregulations. The results from the mean tests on state-level stability indicators are presented by panel 1 in Table 4.2. It shows that the average of the natural logarithm of the main stability indicator, Z score with a 3-year rolling window, is 4.62 prior to the intra-state deregulation, which decreases to 4.15 in the post-deregulation period. The result of the t test shows that the difference between the two means are statistically significant at 1 percent level, which in turn suggests that the state-level stability is on average lower after the deregulation of intra-state banking, compared with the pre-deregulation period. The test based on the inter-state banking deregulation shows similar result: the average of natural logarithm of the Z score (with a 3-year rolling window) over the post-deregulation period (3.84) is significantly lower than that over the pre-deregulation period (4.73).

The test is also conducted based on the occurrence of both type of deregulation: the average of the natural logarithm of the Z score (with a 3-year rolling window)

Table 4.2: Mean Test at State-level

		Before		After		Difference		
Variables	Deregulation	Mean	Obs.	Mean	Obs.	Mean	St. E.	Signif.
Panel 1: State-level Stability Indicators								
	Intra-state	4.62	330	4.15	503	0.47	0.08	***
$log(Z_3)$	Inter-state	4.73	467	3.84	366	0.89	0.07	***
	Both	4.70	283	3.79	319	0.91	0.09	***
	Intra-state	4.17	294	3.78	441	0.40	0.08	***
$log(Z_5)$	Inter-state	4.30	417	3.46	318	0.84	0.07	***
	Both	4.22	249	3.39	273	0.84	0.09	***
	Intra-state	2.68	330	2.30	503	0.38	0.07	***
$log(1/\sigma_3(ROA))$	Inter-state	2.79	467	2.01	366	0.78	0.06	***
	Both	2.74	283	1.97	319	0.77	0.07	***
	Intra-state	2.27	294	1.99	441	0.27	0.06	***
$log(1/\sigma_5(ROA))$	Inter-state	2.39	417	1.72	318	0.67	0.05	***
	Both	2.31	249	1.67	273	0.64	0.07	***
	Intra-state	2.90	143	2.19	445	0.71	0.15	***
NPL Ratio	Inter-state	2.63	176	2.26	412	0.37	0.14	***
	Both	3.17	96	2.24	365	0.93	0.19	***
Panel 2: Banking Sector Control Variables								
	Intra-state	16.85	365	17.10	566	-0.25	0.08	***
Size	Inter-state	16.65	517	17.43	414	-0.78	0.07	***
	Both	16.74	318	17.42	367	-0.67	0.08	***
	Intra-state	0.49	330	0.40	552	0.08	0.03	***
Size Growth	Inter-state	0.55	468	0.30	414	0.25	0.03	***
	Both	0.53	283	0.31	367	0.22	0.03	***
	Intra-state	29.27	365	26.33	566	2.94	0.48	***
C&I Loan	Inter-state	28.92	517	25.69	414	3.24	0.47	***
	Both	29.56	318	25.48	367	4.08	0.56	***
	Intra-state	55.10	365	60.35	566	-5.25	0.46	***
Loan to Assets	Inter-state	56.25	517	60.84	414	-4.59	0.46	***
	Both	54.97	318	61.47	367	-6.49	0.51	***
	Intra-state	30.19	365	24.85	566	5.34	0.50	***
Liquidity	Inter-state	28.14	517	25.44	414	2.71	0.51	***
	Both	30.01	318	24.68	367	5.33	0.59	***
	Intra-state	5.71	365	7.30	566	-1.59	0.22	***
Interbank Borrowing	Inter-state	5.90	517	7.65	414	-1.75	0.22	***
	Both	5.58	318	7.78	367	-2.21	0.24	***

Notes: This table presents the results from a simple mean test on the effect of the competition shocks induced by the two types of deregulations at state-level. Refer to 4.1 for the definition on the state-level variables.

over the period where neither of the two types of deregulation occurred is 4.70, which is significantly higher than that over the period where both intra- and inter-state banking are deregulated (3.79). Overall, these results suggest that the state-level banking stability measured by the Z score with a 3-year rolling window is on average lower over the post-deregulation period.

The results from the tests on the Z score with a 5-year rolling window, inverse standard deviation of ROA with a 3- and 5-year rolling window all point to a similar implication that the state-level banking stability decreased over the post-deregulation period. However, the result from the test on non-performing loan ratio suggests that non-performing loans as a proportion of total loans significantly decreased over the post-deregulation period, which indicates an improvement in banking stability.

Panel 2 in Table 4.2 show the results from the state-level mean tests on other characteristics of the banking sector. It suggests that the banking sector in a state on average grows significantly bigger in terms of total banking assets after the deregulation, though they grow at a significantly lower pace compared with the pre-deregulation level. The amount of commercial and industrial loans as a proportion of total loans significantly decreased by around 3 percentage points on average after the deregulation, while the amount of total loans as a proportion of total banking assets on average increases significantly by around 5 percent. The amount of liquid assets in the banking system also dropped significantly, and the banks become more interconnected through interbank lending markets over the post-deregulation period as the interbank borrowing significantly increases.

4.4.2 Mean Test at Bank-level

The mean tests are also conducted using bank-level variables. Panel 1 in Table 4.3 presents the results from the mean test on bank-level stability indicators. Different from the test results at state-level, the mean test on all bank-level stability indicators indicates that there is a improvement in stability at bank-level after the deregulation of intra- or inter-state banking. For example, it shows that the average of the natural logarithm of the main stability indicator, Z score with a 3-year rolling window, increased from the pre-deregulation level 4.21 to 4.28 after the the intra-state deregulation. This improvement is statistically significant at 1 percent level. Consistent with the state-level results, the test on bank-level non-performing loan ratio suggests that there is a decrease in non-performing loans as a proportion of banks' total loans, which also suggests that banking stability at bank-level was improved over the post-deregulation period.

In terms of other bank characteristics, the mean test results at bank-level are very consistent with the state-level analysis. As panel 2 in Table 4.3 shows, individual banks tend to grow larger over the post-deregulation period though they grow at a slower pace; commercial and industrial lending as a proportion of banks' total lending decreases after the deregulation while total lending as a proportion of banks' total assets increases; banks tend to hold less liquid assets and they are more interconnected in the interbank lending market over the post-deregulation period.

To sum up, the mean test results suggest that there is a decrease in the banking stability at state-level while bank-level stability is improved given the competition shock caused by the banking deregulation. However, this simple test does not consider other important factors such as time trend or region effect. The analysis then performs a more rigorous regression analysis based on the specifications illustrated by equation (3) - (6), and the results are presented in the next section.

Table 4.3: Mean Test at Bank-level

		Before		After		Difference		
Variables	Deregulation	Mean	Obs.	Mean	Obs.	Mean	St. E.	Signif.
Panel 1: Bank-level Stability Indicators								
	Intra-state	4.21	131,599	4.28	81,724	-0.07	0.00	***
$log(Z_3)$	Inter-state	4.21	133,685	4.26	79,638	-0.05	0.00	***
	Both	4.20	110,393	4.27	58,432	-0.07	0.00	***
	Intra-state	3.57	113,566	3.65	66,892	-0.08	0.00	***
$log(Z_5)$	Inter-state	3.58	115,066	3.63	65,392	-0.05	0.00	***
	Both	3.56	94,309	3.64	46,135	-0.08	0.00	***
	Intra-state	1.75	131,600	1.81	81,726	-0.06	0.00	***
$log(1/\sigma_3(ROA))$	Inter-state	1.76	133,686	1.79	79,640	-0.03	0.00	***
	Both	1.75	110,394	1.80	58,434	-0.05	0.00	***
	Intra-state	1.48	113,569	1.56	66,895	-0.07	0.00	***
$log(1/\sigma_5(ROA))$	Inter-state	1.49	115,070	1.54	65,394	-0.04	0.00	***
	Both	1.48	94,312	1.54	46,137	-0.07	0.00	***
	Intra-state	2.66	63,186	1.90	85,450	0.76	0.02	***
NPL Ratio	Inter-state	2.73	54,677	1.92	93,959	0.81	0.02	***
	Both	2.88	40,796	1.82	71,569	1.06	0.02	***
Panel 2: Bank-level Control Variables								
	Intra-state	10.25	148,554	10.98	97,647	-0.72	0.01	***
Size	Inter-state	10.26	151,805	10.99	94,396	-0.73	0.01	***
	Both	10.19	126,139	11.10	71,981	-0.91	0.01	***
	Intra-state	0.98	134,284	0.82	95,476	0.17	0.01	***
Size Growth	Inter-state	1.06	136,232	0.70	93,528	0.37	0.01	***
	Both	1.06	112,049	0.72	71,293	0.34	0.01	***
	Intra-state	21.59	148,483	19.99	97,388	1.60	0.06	***
C&I Loan	Inter-state	21.97	151,697	19.34	94,174	2.63	0.06	***
	Both	21.87	126,093	19.13	71,784	2.75	0.06	***
	Intra-state	53.22	148,531	54.42	97,540	-1.20	0.06	***
Loan to Assets	Inter-state	53.50	151,767	54.00	94,304	-0.50	0.06	***
	Both	53.48	126,120	54.71	71,893	-1.23	0.07	***
	Intra-state	35.35	148,554	33.23	97,646	2.13	0.06	***
Liquidity	Inter-state	35.08	151,805	33.60	94,395	1.48	0.06	***
	Both	35.14	126,139	32.68	71,980	2.47	0.07	***
	Intra-state	1.16	148,554	1.51	97,646	-0.35	0.02	***
Interbank Borrowing	Inter-state	1.21	151,805	1.44	94,395	-0.22	0.02	***
	Both	1.16	126,139	1.53	71,980	-0.37	0.02	***

Notes: This table presents the results from a simple mean test on the effect of the competition shocks induced by the two types of deregulations at bank-level. Refer to 4.1 for the definition on the bank-level variables.

4.5 Results

As described in previous sections, this research exploit the staggered feature of the U.S. banking deregulation as a natural experiment to identify whether the competition shock induced by the policy change would have an impact on banking stability. Based on the regression specifications expressed by equation (3) - (6), it analyses the effect of the competition shock on banking stability at both state-level and bank-level. Dynamic difference-in-difference method is also employed to check the causality between the competition shock and banking stability. In addition, the regressions are also performed with alternative indicators for banking stability to make sure the result is not driven by the variations in the main stability indicator.

For bank-level analysis, the regression analysis are also conducted with a balance panel dataset, to rule out the effect of bank entry and failure on the estimated impact. Furthermore, the analysis continues to explore the heterogeneity among individual banks with the balanced panel. The regression results are presented in the rest of this section.

4.5.1 State-level Analysis: Baseline result

The baseline regression results for the state-level analysis are presented in Table 4.4. Dummy variable *Intra* and *Inter* are the key terms in these regressions as they capture the competition shock introduced by the specific deregulation policies. The regression analysis starts with a simple specification. As column 1 in Table 4.4 shows, it regresses the main stability indicator, logarithm of state-level Z score with a 3-year rolling window ($log(Z_3)$), on the dummy vairbale *Intra* and a constant, with the state fixed effect. The coefficient on the key term, *Intra*, is estimated to be -0.476 from this simple regression, and this effect is statistically significant at 1 percent level. It suggests that there is a decrease in banking stability at state-level given the competition shock induced by the implementation of intra-state bank branching policy, which is consistent with the findings from the state-level mean test analysis. However, this simple regression specification does not control for factors other than the state fixed effect thus the result could be driven by the omitted factors, especially the time effect.

In the second column in Table 4.4, the time fixed effect is introduced into the model and there is a noticeable change in the estimated coefficient on the dummy variable *Intra*: it turns to be positive and also statistically significant, which indicates that there is an improvement in state-level banking stability. This noticeable change clearly shows that the negative estimation in column 1 is driven by omitted time effect. The estimated R^2 suggests that the model with time fixed effect is preferred as it increases from 20.4% in column 1 to 44.5% in column 2.

In term of interpretation on the estimated coefficient in log-linear model, there is a major difference between continuous variables and dummy variables. The estimated coefficient on a continuous variable in a log-linear model can be interpreted as the percentage effect of the specific variable on the outcome variable. However, as Kennedy (1981) suggested, the percentage effect of the dummy variable has to be estimated based on the following equation:

$$\hat{p} = 100 * (\exp[\hat{c} - \frac{1}{2} * \hat{V}(\hat{c})] - 1) \tag{4.7}$$

where $\hat{c}$ is the estimated coefficient on the dummy variable, and $\hat{V}(\hat{c})$ is the estimated variance in the estimated coefficient.

Thus, the estimated coefficient 0.637 with a standard error 0.21 in the second column in Table 4.4 indicates that the banking stability at state-level is improved on average by 85% in the post intra-state deregulation period. This implies that the positive effect of the competition shock induced by the intra-state branching dereg-

Table 4.4: State-level Baseline Result

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	$log(Z_3)$	$log(Z_3)$	$log(Z_3)$	$log(Z_3)$	$log(Z_3)$	$log(Z_3)$
Intra	-0.476***	0.673***	0.460***	0.381***		0.381***
	(0.152)	(0.210)	(0.167)	(0.128)		(0.128)
Inter					-0.019	-0.013
					(0.195)	(0.186)
Banking Sector Controls						
Size			-0.520	-0.600	-0.775*	-0.602
			(0.442)	(0.396)	(0.436)	(0.401)
Size Growth			0.615***	0.466***	0.495***	0.467***
			(0.217)	(0.148)	(0.151)	(0.148)
Interbank Borrowing			0.027	0.020	0.020	0.020
			(0.019)	(0.014)	(0.015)	(0.014)
Liquidity			-0.033	-0.040	-0.044*	-0.040
			(0.021)	(0.025)	(0.026)	(0.025)
C&I Loan			0.033*	0.037**	0.032**	0.037**
			(0.017)	(0.015)	(0.015)	(0.015)
Loan to Assets			-0.014	-0.018	-0.022	-0.018
			(0.022)	(0.025)	(0.026)	(0.025)
Economic Condition Controls						
GDP Growth			0.002	-0.000	0.003	-0.000
			(0.017)	(0.012)	(0.012)	(0.012)
Unemployment			-0.159***	-0.171***	-0.165***	-0.171***
			(0.057)	(0.049)	(0.049)	(0.050)
Housing Price Index			-1.400***	-0.332	-0.325	-0.335
			(0.442)	(0.610)	(0.674)	(0.600)
Constant	4.627***	5.057***	20.861***	18.452**	22.176**	18.511**
	(0.092)	(0.112)	(7.724)	(8.193)	(9.063)	(8.288)
No. of States	49	49	49	49	49	49
Observations	833	833	833	833	833	833
R-squared	0.204	0.445	0.549	0.682	0.675	0.682
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE		Yes	Yes	Yes	Yes	Yes
BEA Region*Year FE				Yes	Yes	Yes

Notes: This table presents the baseline regression results for the state-level analysis. Dummy variable *Intra* and *Inter* are the key terms in these regressions as they capture the competition shock introduced by the specific deregulation policies. The regression analysis starts with a simple specification. As column 1 shows, the coefficient on the key term, *Intra*, is estimated to be -0.476, which is statistically significant at 1 percent level. It suggests that there is a decrease in banking stability at state-level given the competition shock induced by the implementation of intra-state bank branching policy. However, this simple regression specification does not control for factors other than the state fixed effect thus the result could be driven by the omitted factors. In the second column, the time fixed effect is introduced into the model and there is a noticeable change in the estimated coefficient on the key dummy variable: it turns to be positive and also statistically significant, which indicates that there is an improvement in state-level banking stability. This noticeable change clearly shows that the negative estimation in column 1 is driven by omitted time effect. Other control variables are then introduced into the model as it shows in column 3 and 4. The estimated coefficient on the dummy variable *Intra* decreases from 0.673 to 0.460 in column 3. It also shows that the size of a banking sector in a individual state do not have a significant effect on banking stability, while the year-on-year growth of the size is positively and significantly associated with banking stability. The proportion of commercial and industrial loans (*C&L loans*) is also estimated to be positive and significant. Interconnectness, liquidity and loan to asset ratio of a banking sector are all estimated to be insignificantly associated with state-level banking stability. GDP growth of a state does not have a significant effect on banking stability in the state, while the increase in unemployment rate and housing price can destabilise the state's banking sector. Column 4 presents the results estimated with the full specification where region-year fixed effect is included to control for all types of time-varying regional factors which would have am impact on banking stability. As it shows, the estimated coefficient on the key term *Intra* is further decreased to 0.381 with an even smaller standard error of 0.128. Based on the calculation proposed by Kennedy (1981), the percentage effect of the dummy variable is estimated to be 45.2%: state-level banking stability is improved by 45.2% by the intensified intra-state competition in the banking sector. The analysis continues with the full specification. In column 5, the estimated coefficient on *Inter* is negative but insignificant. In the last column, dummy variables *Intra* and *Inter* are both introduced into the model. The results are very consistent with the previous estimations.

ulation on state-level banking stability is not just statistically but also economically significant.

Along with the state and year fixed effect, other control variables are then introduced into the model, and the results are presented by column 3 in Table 4.4. As it shows, though it is still statistically significant at 1 percent level, the estimated coefficient on the dummy variable *Intra* decreases from 0.673 to 0.460 with a smaller standard error. Though it indicates that the percentage effect of the competition shock decreases from 85% to 56%, the scale of this effect is still economically significant.

Column 3 in Table 4.4 also shows that the size of a banking sector in a individual state do not have a significant effect on banking stability, while the year-on-year growth of the size is positively and significantly associated with banking stability: 1 percentage point increase in the size growth rate of the banking sector would improve banking stability in the state by 61.5%. The proportion of commercial and industrial loans (*C&L loans*) is also estimated to be positive and significant: banking stability in a specific state would be improved by 3.3% if the proportion of C&L loans of the banking sector increases by 1 percentage point. Interconnectness, liquidity and loan to asset ratio of a banking sector are all estimated to be insignificantly associated with state-level banking stability.

Indicators for state-level macroeconomic conditions are also added into the model as control variables. As it shows in column 3 in Table 4.4, GDP growth of a state does not have a significant effect on banking stability in the state. However, the increase in unemployment rate and housing price can destabilise the state's banking sector, as the coefficient on unemployment rate and housing price index are both estimated to be negative and significant. Compared with the previous model specification in column 2, the goodness of fit of the model is also improved with the control variables:

55% of variations in state-level banking stability is explained by the current model.

Column 4 in Table 4.4 presents the results estimated with the full specification where region-year fixed effect is introduced into the model. The Bureau of Economic Analysis (BEA) divides the United States into eight regions for the purpose of economic and statistical analysis, and each region contains several states.[3] Thus, including the BEA region-year fixed effects in the model controls for all types of time-varying regional factors which would have am impact on banking stability. As it shows in column 4, the estimated coefficient on the key term $Intra$ is further decreased to 0.381 with an even smaller standard error of 0.128. Based on the calculation proposed by Kennedy (1981), the percentage effect of the dummy variable is estimated to be 45.2%: state-level banking stability is improved by 45.2% by the intensified intra-state competition in the banking sector. Though the effect of housing price level on banking stability is estimated to be insignificant with this full specification, the estimates on all other control variables remain qualitatively the same. Introducing the BEA region-year fixed effect into the model further improves the estimated R^2 to 68.2%, indicating that some variations in banking stability indeed can be explained by the time-varying regional factors that should not be omitted in the model.

The analysis continues with the full specification. In column 5 in Table 4.4, the dummy variable $Inter$ is replace by $Inter$ to explore the effect of inter-state competition induced by the inter-state branching deregulation on banking stability. As it shows, the estimated coefficient on $Inter$ is negative but insignificant, which suggests that the policy change does not have a significant effect on banking stability. The insignificant result might be due to the fact that the inter-state banking deregulation is levied by individual states on a basis of state-level reciprocation.

[3]The eight BEA regions are: New England, Mideast, Southeast, Great Lakes Region, Plains Region, Rocky Mountain Region, Southwest and Far West Region. See Figure A4.1 in the appendix for the mapping of BEA regions.

For instance, even if a state declare to deregulate their banking system and allow the entry of banks from other states, the banking sector would not be exposed to outside competition if no other state reach an agreement with this state on the issue of inter-state banking. Thus, the timing of inter-state deregulation might not be relevant in terms of measuring inter-state banking competition shocks. In terms of control variables, the estimations on size and liquidity of the banking sector change slightly and turn to be negative and significant. Estimations on all other variables remain qualitatively the same.

Finally, in the last column in Table 4.4, dummy variables *Intra* and *Inter* are both introduced into the model. The results are very consistent with the previous estimations. To sum up, the intensified intra-state banking competition significantly improves the state-level banking stability on average by 45.2% while the inter-state banking deregulation is estimated to have an insignificant impact on banking stability. The growth rate of the size of a banking sector and the proportion of commercial and industrial loans are estimated to have a negative and significant association with banking stability. The banking system of a state could be significantly destabilised by higher unemployment rate in the state. Overall, the key results are consistent with the competition-stability hypothesis in the literature.

4.5.2 State-level Analysis: Dynamic DID result

The baseline results from the typical difference-in-difference (DID) regressions show that higher level of banking competition induced by the intra-state banking deregulation would have a positive impact on the state-level banking stability. Following regression specifications illustrated by equation (5) - (6), dynamic difference-in-difference method is also employed in this analysis to confirm the causality identified by the typical DID method. The results from the state-level dynamic DID regressions are presented by Table 4.5.

As the bottom of Table 4.5 shows, all these regressions follow the full specification where the state-level control variables, state fixed effect, year fixed effect and the BEA region-year fixed effect are all included. The first column in Table 4.5 shows that the key term in the typical DID setting, $Intra$, is decomposed with four dummy variables capturing the timing of the deregulation. *Pre-intra*$_{3-1}$ is a dummy variable for the periods 3, 2, and 1 years before the implementation year of the intra-state deregulation; $Intra_{0-2}$ is a dummy variable for the implementation year and 1 and 2 years after that year. Similarly, $Intra_{3-5}$ is a dummy variable for the period 3-5 years after the implementation year while $Intra_{6+}$ is a dummy variable for the period at least 6 years after the implementation year. The first column in Table 4.5 shows that the coefficient on *Pre-intra*$_{3-1}$ is estimated to be insignificant while estimations on the other three dummy variables are all positive and significant. The insignificant estimation on *Pre-intra*$_{3-1}$ shows that there is no significant difference between states in the treatment group and those in the control group before the competition shock comes into play.

Similarly, column 2 in Table 4.5 shows that the dummy variable $Inter$ in the typical DID setting is also decomposed into four dummy variables. However, none of the four dummy variables are estimated to be statistically significant, which implies that the inter-state branching deregulation does not significantly affect the state-level banking stability. In column 3, the dynamic DID terms are all included into the single regression, and the estimations do not qualitatively differ from those in column 1 and 2.

Figure 4.4 graphically presents the estimated effect of the competition shock induced by both types of deregulation on banking stability. As the left panel in Figure 4.4 shows, the estimated effect on the period 3-1 (3 to 1 years before the intra-state

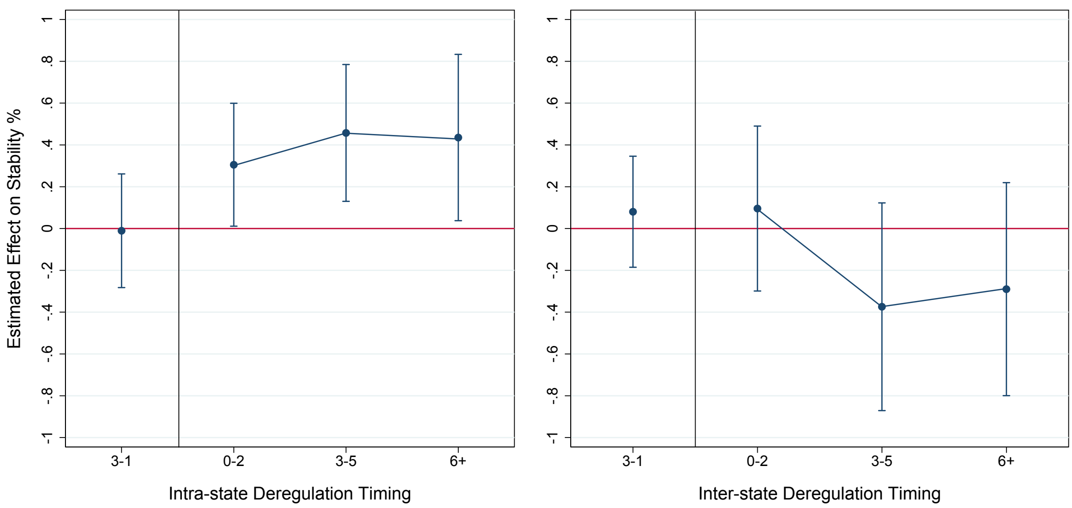
Table 4.5: State-level Dynamic DID Result

	(1)	(2)	(3)
Variables	$log(Z_3)$	$log(Z_3)$	$log(Z_3)$
Pre-intra $_{3-1}$	0.021		-0.011
	(0.163)		(0.168)
Intra $_{0-2}$	0.340*		0.305*
	(0.180)		(0.182)
Intra $_{3-5}$	0.491**		0.457**
	(0.201)		(0.202)
Intra $_{6+}$	0.452*		0.435*
	(0.245)		(0.246)
Pre-inter $_{3-1}$		0.075	0.080
		(0.162)	(0.164)
Inter $_{0-2}$		0.083	0.096
		(0.255)	(0.244)
Inter $_{3-5}$		-0.403	-0.374
		(0.340)	(0.307)
Inter $_{6+}$		-0.366	-0.290
		(0.364)	(0.315)
No. of States	49	49	49
Observations	833	833	833
R-squared	0.683	0.684	0.691
State-level Controls	Yes	Yes	Yes
State FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
BEA Region*Year FE	Yes	Yes	Yes

Notes: This table presents the results from the state-level dynamic difference-in-difference regressions. Refer to Table 4.4 for full model specification. The first column shows that the key term in the typical DID setting, *Intra*, is decomposed with four dummy variables capturing the timing of the deregulation. $Pre\text{-}intra_{3-1}$ is a dummy variable for the periods 3, 2, and 1 years before the implementation year of the intra-state deregulation; $Intra_{0-2}$ is a dummy variable for the implementation year and 1 and 2 years after that year. Similarly, $Intra_{3-5}$ is a dummy variable for the period 3-5 years after the implementation year while $Intra_{6+}$ is a dummy variable for the period at least 6 years after the implementation year. As it shows in column 1, the coefficient on $Pre\text{-}intra_{3-1}$ is estimated to be insignificant while estimations on the other three dummy variables are all positive and significant. The insignificant estimation on $Pre\text{-}intra_{3-1}$ indicates that there is no significant difference between states in the treatment group and those in the control group before the competition shock come into play. Similarly, column 2 in Table 4.5 shows that the dummy variable *Inter* in the typical DID setting is also decomposed into four dummy variables. However, none of the four dummy variables are estimated to be statistically significant. In column 3, the dynamic DID terms are all included into the single regression, and the estimations do not qualitatively differ from those in column 1 and 2. Overall the results from the dynamic DID regressions confirms the causality between the intra-state banking competition shock and banking stability which has been identified from the baseline results, as the common trend assumption of the DID method is satisfied in this case. It also shows that inter-state branching deregulation does not significantly affect the state-level banking stability, which is also consistent with the findings from the typical DID setting.

deregulation) is not significantly different from zero, which means that banking stability in these periods are not significantly changed relative to the previous periods. However, after the implementation of the intra-state deregulations as indicated by the vertical line in the box, there is consistent and significant improvement in banking stability given the intensified intra-state banking competition. The right panel in Figure 4.4 indicates that the state-level banking stability is not significantly affected by the implementation of the inter-state branching deregulation, as the estimated effect on all the dummy variables are not significantly different from zero.

Figure 4.4: Dynamics in Estimated DID Effects on State-level Banking Stability



Notes: This figure graphically presents the estimated effect of the competition shock induced by both types of deregulation on banking stability at state level. As the left panel shows, the estimated effect on the period 3-1 (3 to 1 year before the intra-state deregulation) is not significantly different from zero, which means that banking stability in these periods are not significantly changed relative to the previous periods. However, after the implementation of the intra-state deregulations as indicated by the vertical line in the box, there is consistent and significant improvement in banking stability given the intensified intra-state banking competition. The right panel indicates that the state-level banking stability is not significantly affected by the implementation of the inter-state branching deregulation, as the estimated effect on all the dummy variables are not significantly different from zero.

Overall the results from the dynamic DID regressions confirms the causality between the intra-state banking competition shock and banking stability which has been identified from the baseline results, as the common trend assumption of the DID method is satisfied in this case. It also shows that inter-state branching deregulation does not significantly affect the state-level banking stability, which is also consistent with the findings from the typical DID setting.

4.5.3 State-level Analysis: Alternative stability indicators

Following Beck et al. (2013), the main indicator for banking stability in this analysis is Z score calculated with a 3-year rolling window (Z_3). To make sure the results are not solely driven by the specific pattern and variation in the main stability indicator Z_3, the typical DID regressions are also implemented with alternative stability indicators to confirm the findings from the previous analysis. As described in Section 4, the alternative indicators are: Z score with a 5-year rolling window (Z_5), inverse standard deviation of ROA with a 3-year rolling window, inverse standard deviation of ROA with a 5-year rolling window and non-performing loan ratio (NPL Ratio).

The regression results with alternative state-level banking stability indicators are presented in Table 4.6, along with the result estimated from the main indicator in the first column. Column 2 in Table 4.6 presents the regression results with Z_5 as the state-level stability indicator. Compared with the results in column 1, it shows that the number of observations decreases from 833 to 735 as the rolling window widened, meanwhile the estimated coefficient on the key terms - $Intra$ and $Inter$ - are qualitatively unchanged. Based on Kennedy (1981)'s method of interpretation illustrated by equation 7, an estimation of 0.303 on $Intra$ with a standard error of 0.125 means that the state-level banking stability are estimated to be improved by 34.3% given the intensified competition after the intra-state branching deregulation, and this effect is statistically significant at 5 percent level. The insignificant estimation on $Inter$ also confirms the findings from the first column that the state-level banking stability is not significantly influence by the inter-state branching deregulation.

Table 4.6: State-level Result - Alternative Stability Indicators

	(1)	(2)	(3)	(4)	(5)
Variables	$log(Z_3)$	$log(Z_5)$	$log(1/\sigma_3(ROA))$	$log(1/\sigma_5(ROA))$	NPL Ratio
Intra	0.381***	0.303**	0.371***	0.298***	-0.499***
	(0.128)	(0.125)	(0.108)	(0.105)	(0.181)
Inter	-0.013	0.054	-0.001	0.063	-0.070
	(0.186)	(0.152)	(0.161)	(0.126)	(0.157)
No. of States	49	49	49	49	49
Observations	833	735	833	735	588
R-squared	0.682	0.771	0.657	0.746	0.811
State-level Controls	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
BEA Region*Year FE	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the regression results with alternative state-level banking stability indicators, along with the result estimated from the main indicator in the first column. Refer to Table 4.4 for full model specification. Column 2 presents the regression results with Z_5 as the state-level stability indicator. It shows that the number of observations decreases to 735 as the rolling window widened, meanwhile the estimated coefficient on the key terms - $Intra$ and $Inter$ - are qualitatively unchanged. The insignificant estimation on $Inter$ also confirms the findings from the first column that the state-level banking stability is not significantly influence by the inter-state branching deregulation. These findings are also confirmed by the positive and significant estimations on $Intra$ and the insignificant estimations on $Inter$ in both column 3 and 4 where the state-level banking stability are indicated by the inverse standard deviation of ROA with a 3- and 5-year rolling window, respectively. Column 5 presents the regression results with NPL Ratio as the state-level banking stability indicator. The number of observations in this regression further drops to 588, as the information on non-performing loans in the Call report is only available from 1983 onward. The estimation on $Intra$ also confirms the finding that the state-level banking stability is improved by the intensified intra-state banking competition over the post-deregulation period.

These findings are also confirmed by the positive and significant estimations on $Intra$ and the insignificant estimations on $Inter$ in both column 3 and 4 in Table 4.6 where the state-level banking stability are indicated by the inverse standard deviation of ROA with a 3- and 5-year rolling window, respectively. Column 5 in Table 4.6 presents the regression results with NPL Ratio as the state-level banking stability indicator. The number of observations in this regression drops to 588 from 833 in the benchmark regression, as the information on non-performing loans in the Call report is only available from 1983 onward. The estimation on $Intra$ suggests that the state-level non-performing loan ratio on average decreases by 0.499 percentage points after the intra-state deregulation, which also confirms the finding that the state-level banking stability is improved by the intensified intra-state banking competition over the post-deregulation period.

To sum up the state-level analysis, evidence from the typical DID regressions, dynamic DID regressions and regressions with alternative state-level banking stability indicators all suggest that the intensified banking competition caused by intra-state branching deregulation improves the banking stability at the state-level, and the effect is both statistically and economically significant.

4.5.4 Bank-level Analysis: Baseline result

The Baseline regression results for the bank-level analysis are presented in Table 4.7. As it shows, these regressions follow the full specification where the bank fixed effect, year fixed effect and the BEA region-year fixed effect are all included. Furthermore, each regression in the bank-level analysis also controls for bank specific characteristics and state-level macroeconomic conditions.

As the first column of Table show, the dummy variable $Intra$ is introduced into the regression indicating the intensified competition level after the intra-state branching deregulation. It shows that the estimated coefficient on $Intra$ is positive and statistically significant at 5 percent level. Using the interpretation method proposed by Kennedy (1981), the estimation of 0.019 on $Intra$ with a standard error of 0.009 means that the bank-level stability is on average improved by 1.914% in the more competitive environment after the intra-state branching deregulation. Though the effect of the intensified intra-state competition on bank-level stability is estimated to be consistent with that estimated in the state-level analysis, the scale of the improvement in banking stability at bank-level is much smaller than that at the state-level.

In the second column in Table 4.7, the dummy variable $Intra$ is replace by $Inter$

Table 4.7: Bank-level Baseline Result

	(1)	(2)	(3)
Variables	$log(Z_3)$	$log(Z_3)$	$log(Z_3)$
Intra	0.019**		0.021**
	(0.009)		(0.009)
Inter		0.023**	0.026**
		(0.010)	(0.010)
Bank-level Controls			
Size	0.098***	0.097***	0.097***
	(0.009)	(0.009)	(0.009)
Size Growth	-0.003***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.001)
Interbank Borrowing	-0.003***	-0.003***	-0.003***
	(0.001)	(0.001)	(0.001)
Liquidity	0.003***	0.003***	0.003***
	(0.000)	(0.000)	(0.000)
C&I Loan	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Loan to Assets	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
State-level Controls			
GDP Growth	0.006***	0.006***	0.006***
	(0.001)	(0.001)	(0.001)
Unemployment	-0.039***	-0.037***	-0.038***
	(0.003)	(0.003)	(0.003)
Housing Price Index	-0.008	-0.026	-0.018
	(0.046)	(0.046)	(0.046)
Constant	3.516***	3.596***	3.535***
	(0.248)	(0.247)	(0.249)
No. of Banks	16,410	16,410	16,410
Observations	213,154	213,154	213,154
R-squared	0.385	0.385	0.385
Bank FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
BEA Region*Year FE	Yes	Yes	Yes

Notes: This table presents the baseline regression results for the bank-level analysis. Column 1 shows that the estimated coefficient on $Intra$ is positive and statistically significant at 5 percent level. The estimation of 0.019 on $Intra$ with a standard error of 0.009 means that the bank-level stability is on average improved by 1.914% in the more competitive environment after the intra-state branching deregulation. Column 2 shows that the coefficient on $Inter$ is also estimated to be positive and statistically significant at 5 percent level, and the scale of the effect is calculated to be 2.321%. Column 3 shows that the coefficient estimated on $Intra$ and $Inter$ are qualitatively the same compared with the estimations in column 1 and 2 respectively. Overall, the results suggest that banking stability at bank-level is improved by the intensified level of competition caused by both types of banking deregulation. Furthermore, bank size is positively and significantly associated with bank-level stability. However, the year-on-year growth of bank size is estimated to have a negative and significant effect on bank-level stability, which indicates that banks that expand in a faster pace might be using more aggressive strategies that generates excessive risks. The estimation on $InterbankBorrowing$ implies that banks relying more on the funding from the interbank market tend to be less stable. The liquidity condition of a bank is estimated to have a positive and significant association with its stability. It also suggests that the business model of a bank, as indicated by the proportion of commercial and industrial loans ($C\&L$ $loans$) in a bank's loan portfolio and the Loan to Assets ratio, does not have a significant effect on the bank's stability. Furthermore, it shows that state-level macroeconomic conditions also matter for banking stability at bank-level.

which indicates the inter-state banking competition shock induced by the inter-state branching deregulation. The coefficient on $Inter$ is also estimated to be positive and statistically significant at 5 percent level, and the scale of the effect is calculated to be 2.321%. The result is different from that in the state-level analysis which implies that inter-state branching deregulation does not have an impact on banking stability at state-level.

Column 3 in Table 4.7 presents the regression results where both $Intra$ and $Inter$ are introduced into the model. As it shows, the coefficient estimated on $Intra$ and $Inter$ are qualitatively the same compared with the estimations in column 1 and 2 respectively. Overall, the results suggest that banking stability at bank-level is improved by the intensified level of competition caused by both types of banking deregulation.

In terms of bank-level control variables, column 3 in Table 4.7 shows that bank size is positively and significantly associated with bank-level stability: if a bank's size increases by 1%, the stability of the bank would be improved by 9.7%. However, the year-on-year growth of bank size is estimated to have a negative and significant effect on bank-level stability: 1 percentage point increase in the annual growth rate of a bank's size would reduce the bank's stability by 0.3%. This indicates that banks that expand in a faster pace might be using more aggressive strategies that generates excessive risks. The estimation on $InterbankBorrowing$ shows that 1 percentage point increase in a bank's interbank borrowing would reduce the bank's stability by 0.3%, implying that banks relying more on the funding from the inter-bank market tend to be less stable. The liquidity condition of a bank is estimated to have a positive and significant association with its stability: if the liquid assets of a bank increases by 1 percentage point, the stability of the bank would be improved by 0.3%. It also suggests that the business model of a bank, as indicated by the proportion of commercial and industrial loans (*C&L loans*) in a bank's loan portfolio and the Loan to Assets ratio, does not have a significant effect on the bank's stability. Furthermore, it shows that state-level macroeconomic conditions also matter for banking stability at bank-level: 1 percentage point increase in GDP growth would improve bank-level stability by 0.6%, while 1 percentage point increase in unemployment rate would reduce bank-level stability by 3.8%.

4.5.5 Bank-level Analysis: Dynamic DID result

As in the state-level analysis, dynamic difference-in-difference method is also implemented in the bank-level analysis to examine the causality between the competition shock induced by both types of branching deregulation and bank-level stability. Table 4.8 presents the results from the bank-level dynamic DID regressions.

As it shows in the first column in Table 4.8, the key dummy variable in the typical DID setting, $Intra$, is decomposed into four dummy variables based on the regression specification illustrated by equation 6. $Pre\text{-}intra_{3-1}$ is the dummy variable for the pre-deregulation period while $Intra_{0-2}$, $Intra_{3-5}$ and $Intra_{6+}$ are the dummy variables for the post-deregulation period, capturing the intensified intra-state competition shock caused by the intra-state branching deregulation. It shows that $Pre\text{-}intra_{3-1}$ is estimated to be insignificant which indicates that there is no significant difference between banks in the treatment group and those in the control group before the intra-state competition shock comes into play. Meanwhile, $Intra_{3-5}$ and $Intra_{6+}$ are estimated to be positive and significant at 1 percent level. The result confirms the causality between the intensified intra-state competition shock and bank-level stability.

Similarly, column 2 in Table 4.8 shows that the dummy variable *Inter* in the typical DID setting is also decomposed into four dummy variables. The dummy

Table 4.8: Bank-level Dynamic DID Result

	(1)	(2)	(3)
Variables	$log(Z_3)$	$log(Z_3)$	$log(Z_3)$
Pre-intra $_{3-1}$	0.006		0.005
	(0.008)		(0.009)
Intra $_{0-2}$	0.019		0.022*
	(0.012)		(0.012)
Intra $_{3-5}$	0.049***		0.049***
	(0.015)		(0.015)
Intra $_{6+}$	0.074***		0.073***
	(0.021)		(0.021)
Pre-inter $_{3-1}$		0.001	-0.000
		(0.010)	(0.010)
Inter $_{0-2}$		0.025*	0.024
		(0.015)	(0.015)
Inter $_{3-5}$		-0.014	-0.015
		(0.020)	(0.020)
Inter $_{6+}$		-0.010	-0.012
		(0.026)	(0.026)
No. of Banks	16,410	16,410	16,410
Observations	213,154	213,154	213,154
R-squared	0.385	0.385	0.385
Bank Controls	Yes	Yes	Yes
State Controls	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
BEA Region*Year FE	Yes	Yes	Yes

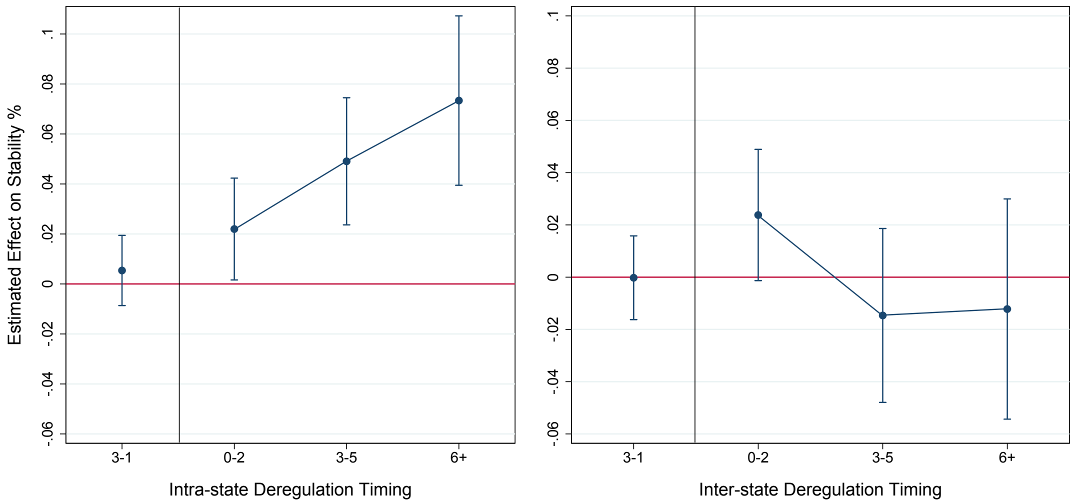
Notes: This table presents the results from the bank-level dynamic DID regressions. Refer to Table 4.7 for full model specification. First column shows that the key dummy variable in the typical DID setting, $Intra$, is decomposed into four dummy variables based on the regression specification illustrated by equation 6. $Pre\text{-}intra_{3-1}$ is the dummy variable for the pre-deregulation period while $Intra_{0-2}$, $Intra_{3-5}$ and $Intra_{6+}$ are the dummy variables for the post-deregulation period, capturing the intensified intra-state competition shock caused by the intra-state branching deregulation. It shows that $Pre\text{-}intra_{3-1}$ is estimated to be insignificant which indicates that there is no significant difference between banks in the treatment group and those in the control group before the intra-state competition shock comes into play. Meanwhile, $Intra_{3-5}$ and $Intra_{6+}$ are estimated to be positive and significant at 1 percent level. Similarly, column 2 in shows that the dummy variable $Inter$ in the typical DID setting is also decomposed into four dummy variables. The dummy variable for the pre-deregulation period ($Pre\text{-}inter_{3-1}$) is estimated to be insignificant, while the the first dummy variable for the post-deregulation period ($Inter_{0-2}$) is estimated to be positive and significant. However, the estimation on the other two post-deregulation dummy variables, $Inter_{3-5}$ and $Inter_{6+}$ are not statistically significant. In the last column, the dynamic DID terms for both types of deregulation are all included into the regression. As it shows, the estimations on the dummy variables for the intra-state deregulation are qualitatively the same as in column 1, apart from the fact that the the first post-deregulation dummy variable ($Intra_{0-2}$) turns to be positive and significant. This confirms that the banking stability at bank-level is improved given the competition shock induced by the intra-state branching deregulation. In terms of the inter-state deregulation, column 3 shows that none of the four dummy variables are estimated to be significant, indicating that the findings from the typical DID regressions are not robust with the dynamic DID setting.

variable for the pre-deregulation period ($Pre\text{-}inter_{3-1}$) is estimated to be insignificant, while the the first dummy variable for the post-deregulation period ($Inter_{0-2}$) is estimated to be positive and significant. However, the estimation on the other two post-deregulation dummy variables, $Inter_{3-5}$ and $Inter_{6+}$ are not statistically significant. This provide weak evidence on the causality between the inter-state competition shock on bank-level stability.

In the last column in Table 4.8, the dynamic DID terms for both types of deregulation are all included into the regression. As it shows, the estimations on the dummy variables for the intra-state deregulation are qualitatively the same as in column 1, apart from the fact that the the first post-deregulation dummy variable ($Intra_{0-2}$) turns to be positive and significant. Again, this confirms that the banking stability at bank-level is improved given the competition shock induced by the intra-state branching deregulation. In terms of the inter-state deregulation, column 3 shows that none of the four dummy variables are estimated to be significant, indicating that the findings from the typical DID regressions are not robust with the dynamic DID setting.

The estimated effects of the competition shock caused by both type of deregulations in column 3 are also graphically presented in Figure 4.5. The left panel in Figure 4.5 shows that the estimated effect on the period 3-1 (3 to 1 years before the intra-state deregulation) is not significantly different from zero, which means that bank-level stability in these periods are not significantly changed relative to the previous periods. However, after the implementation of the intra-state deregulations as indicated by the vertical line in the box, there is progressive and significant improvement in bank-level stability given the intensified intra-state banking competition. The right panel in Figure 4.5 indicates that the bank-level stability is not significantly affected by the implementation of the inter-state branching deregulation, as

Figure 4.5: Dynamics in Estimated DID Effects on Bank-level Banking Stability



Notes: This figure graphically presents the estimated effects of the competition shock caused by both type of deregulations. The left panel shows that the estimated effect on the period 3-1 (3 to 1 years before the intra-state deregulation) is not significantly different from zero, which means that bank-level stability in these periods are not significantly changed relative to the previous periods. However, after the implementation of the intra-state deregulations as indicated by the vertical line in the box, there is progressive and significant improvement in bank-level stability given the intensified intra-state banking competition. The right panel indicates that the bank-level stability is not significantly affected by the implementation of the inter-state branching deregulation, as the estimated effect on all the dummy variables are not significantly different from zero.

the estimated effect on all the dummy variables are not significantly different from zero.

Overall the results from the bank-level dynamic DID regressions confirms the causality between the intra-state banking competition shock and banking stability which has been identified from the baseline results, as the common trend assumption of the DID method is satisfied in this case. It also shows that inter-state branching deregulation does not significantly affect the state-level banking stability. These findings are very consistent with the state-level evidence.

4.5.6 Bank-level Analysis: Alternative stability indicators

Using alternative bank-level banking stability indicators, this section examines the findings from the bank-level analysis in the previous sections, to make sure that the results are not solely driven by the specific pattern and variation in the main stability indicator Z_3. As described in Section 4, the alternative bank-level stability indicators are: Z score with a 5-year rolling window (Z_5), inverse standard deviation of ROA with a 3-year rolling window, inverse standard deviation of ROA with a 5-year rolling window and non-performing loan ratio (NPL Ratio).

The regression results with alternative bankl-level stability indicators are presented in Table 4.9, along with the result estimated from the main indicator in the first column. Column 2 in Table 4.9 presents the regression results with Z_5 as the state-level stability indicator. Compared with the results in column 1, it shows that the number of observations decreases from 213,154 to 180,401 as the rolling window widened, meanwhile the estimated coefficient on the key terms - $Intra$ and $Inter$ - are qualitatively unchanged. This confirms the findings from the typical DID regressions with the main indicator. Furthermore, this result is also confirmed by the estimations in both column 3 and 4 in Table 4.9 where the state-level banking stability are indicated by the inverse standard deviation of ROA with a 3-year and 5-year rolling window, respectively.

Column 5 in Table 4.9 presents the regression results with NPL Ratio as the bank-level stability indicator. The number of observations in this regression further drops 146,780, as the information on non-performing loans in the Call report is only available from 1983 onward. However, the estimations on both $Intra$ and $Inter$ are not statistically significant, which differs from the results in the previous regressions. It suggests that the non-performing loan ratio at bank-level are not significantly influenced by the intensified competition shock induced by both types of branching

Table 4.9: Bank-level Result - Alternative Stability Indicators

	(1)	(2)	(3)	(4)	(5)
Variables	$log(Z_3)$	$log(Z_5)$	$log(1/\sigma_3(ROA))$	$log(1/\sigma_5(ROA))$	NPL Ratio
Intra	0.021**	0.034***	0.044***	0.045***	0.042
	(0.009)	(0.011)	(0.010)	(0.009)	(0.037)
Inter	0.026**	0.020*	0.030***	0.019**	0.024
	(0.010)	(0.011)	(0.011)	(0.009)	(0.038)
No. of Banks	16,410	16,407	16,410	16,407	15,601
Observations	213,154	180,401	213,154	180,403	146,780
R-squared	0.385	0.573	0.398	0.558	0.509
Bank Controls	Yes	Yes	Yes	Yes	Yes
Country Controls	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
BEA Region*Year FE	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the results from the bank-level dynamic DID regressions. Refer to Table 4.7 for full model specification. First column shows that the key dummy variable in the typical DID setting, *Intra*, is decomposed into four dummy variables based on the regression specification illustrated by equation 6. $Pre\text{-}intra_{3-1}$ is the dummy variable for the pre-deregulation period while $Intra_{0-2}$, $Intra_{3-5}$ and $Intra_{6+}$ are the dummy variables for the post-deregulation period, capturing the intensified intra-state competition shock caused by the intra-state branching deregulation. It shows that $Pre\text{-}intra_{3-1}$ is estimated to be insignificant which indicates that there is no significant difference between banks in the treatment group and those in the control group before the intra-state competition shock comes into play. Meanwhile, $Intra_{3-5}$ and $Intra_{6+}$ are estimated to be positive and significant at 1 percent level. Similarly, column 2 in shows that the dummy variable *Inter* in the typical DID setting is also decomposed into four dummy variables. The dummy variable for the pre-deregulation period ($Pre\text{-}inter_{3-1}$) is estimated to be insignificant, while the the first dummy variable for the post-deregulation period ($Inter_{0-2}$) is estimated to be positive and significant. However, the estimation on the other two post-deregulation dummy variables, $Inter_{3-5}$ and $Inter_{6+}$ are not statistically significant. In the last column, the dynamic DID terms for both types of deregulation are all included into the regression. As it shows, the estimations on the dummy variables for the intra-state deregulation are qualitatively the same as in column 1, apart from the fact that the the first post-deregulation dummy variable ($Intra_{0-2}$) turns to be positive and significant. This confirms that the banking stability at bank-level is improved given the competition shock induced by the intra-state branching deregulation. In terms of the inter-state deregulation, column 3 shows that none of the four dummy variables are estimated to be significant, indicating that the findings from the typical DID regressions are not robust with the dynamic DID setting.

deregulation. This result also differs from that in the state-level analysis that there is a significant drop in non-performing loan ratio at state-level after the intra-state deregulation. This might be due to the heterogeneity at bank level: the competition shock affects different types of banks in different ways.

To sum up the bank-level analysis, evidence from the typical DID regressions, dynamic DID regressions and regressions with alternative bank-level banking stability indicators all suggest that the intensified banking competition caused by intra-state branching deregulation significantly improves the banking stability at bank-level. Though the scale of the effect of the intra-state competition on banking stability is much smaller at bank-level, it is still economically significant. Furthermore, the dynamic DID regressions do not show strong evidence that there is a significant improvement in the bank-level stability after the inter-state deregulation. Overall, the bank-level results are consistent with the findings from the state-level analysis.

4.5.7 Bank-level Analysis: Balanced panel

As described in the previous sections, the main dataset in this analysis is the Call report which records financial statements data for all banking institutions regulated by the FDIC. It contains 250,654 observations for 18,012 banks and the sample period starts from 1976 to 1994, with an annual frequency for 19 dates. However, this unbalance panel dataset: some banks are established and recorded by the database after 1976 while some others disappeared before 1994, due to the reason of failure, merger or acquisition. This unbalanced feature of the bank-level data might might potentially affect estimated results from the bank-level regressions. For instance, banks that are failed, merged or acquisitive by others (banks exited the databased before 1994) might be those particularly unstable banks.

This section examines whether the previous findings from the bank-level analysis are driven by the unbalanced feature of the bank-level datasets. To construct a balanced panel dataset at bank-level, those unbalanced observations are dropped from the dataset while only banks that could be observed over the whole sample period are kept. Table 4.10 shows the results estimated from both the typical DID regressions and dynamic DID regressions with the balanced panel dataset. As the bottom of Table 4.10 shows, the number of banks in the balanced panel decreased by 51.1% from 16,410 to 8,107, while accordingly the number of observations decreased by 35.4% from 213,154 to 137,779.

Though there is a significant drop in the number of observations in the balanced panel, the key regression result remain qualitatively unchanged. The first three columns in Table 4.10 present the regression results for the typical DID setting. It shows that the estimations on the key terms - $Intra$ and $Inter$ - are all positive and significant, and the scale of the estimated effect of the competition shock on bank-level stability are very close to those in the baseline results presented in Table 4.7. Furthermore, the estimations in column 4 - 6 are also very close to the regression results presented in Table 4.8 where the dynamic DID is implemented with the unbalance panel dataset. Overall, this consistent result suggests that the previous findings in the bank-level analysis are not biased due to the unbalanced feature of the main dataset.

4.5.8 Bank-level Analysis: Heterogeneity test

The overall bank-level analysis shows that the stability of individual banks is significantly improved by the intensified competition induced by the intra-state branching deregulation, while the inter-state deregulation does not have a long lasting effect on the bank-level stability as indicated by the dynamic DID analysis. These results are very consistent with the finding from the state-level analysis. However, the scale

Table 4.10: Bank-level Result - Balanced Panel

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	$log(Z_3)$	$log(Z_3)$	$log(Z_3)$	$log(Z_3)$	$log(Z_3)$	$log(Z_3)$
Intra	0.019*		0.022**			
	(0.010)		(0.010)			
Inter		0.028**	0.031***			
		(0.012)	(0.012)			
Pre-intra 3-1				0.015		0.014
				(0.010)		(0.010)
Intra 0-2				0.025*		0.029**
				(0.014)		(0.015)
Intra 3-5				0.055***		0.055***
				(0.018)		(0.018)
Intra 6+				0.088***		0.088***
				(0.023)		(0.024)
Pre-inter 3-1					0.008	0.008
					(0.012)	(0.012)
Inter 0-2					0.037**	0.036**
					(0.018)	(0.018)
Inter 3-5					-0.000	-0.000
					(0.024)	(0.024)
Inter 6+					0.008	0.007
					(0.030)	(0.030)
No. of Banks	8,107	8,107	8,107	8,107	8,107	8,107
Observations	137,779	137,779	137,779	137,779	137,779	137,779
R-squared	0.329	0.329	0.329	0.329	0.329	0.330
Bank Controls	Yes	Yes	Yes	Yes	Yes	Yes
State Controls	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Region*Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table shows the results estimated from both the typical DID regressions and dynamic DID regressions with the balanced panel dataset. As the bottom shows, the number of banks in the balanced panel decreased by 51.1% to 8,107, while accordingly the number of observations decreased by 35.4% to 137,779. The first three columns present the regression results for the typical DID setting. It shows that the estimations on the key terms are all positive and significant, and the scale of the estimated effect of the competition shock on bank-level stability are very close to those in the baseline results presented in Table 4.7. Furthermore, the estimations in column 4 - 6 are also very close to the regression results presented in Table 4.8 where the dynamic DID is implemented with the unbalance panel dataset. Overall, this consistent result suggests that the previous findings in the bank-level analysis are not biased due to the unbalanced feature of the main dataset.

of the effect estimated at bank-level are much smaller than the effect estimated from the state-level analysis, which might be due to the heterogeneity at bank level.

In the state level analysis, taking estimations in column 6 in Table 4.4 as an example, the banking stability at state-level is remarkably improved by the intensified intra-state banking competition by 45.2%.[4] Nevertheless, the percentage effect of the same competition shock on bank-level stability is only estimated to be 2.12%, as indicated by the estimations in column 3 in Table 4.7. This suggests that there might be some heterogeneity among individual banks so that the average effect estimated at bank-level is much smaller than that at the state-level.

This section examines the heterogeneity among banks in terms of the effect of the competition shock on bank-level stability. It examines the bank-level heterogeneity from 3 perspectives: bank size, bank profitability, and level of competition. Banks at different scale might react in different ways when they face a common competition shock to the system as they might have distinctive business models and strategies or serve different customers. Bank profitability might have an impact on the channel through which the competition shock would have an effect on bank-level stability. Compared with non-profitable banks, profitable banks might be able to handle the competition shocks more easily. The level of competition before the deregulation also matters, as Martinez-Miera and Repullo (2010) and Hakenes and Schnabel (2011) suggest that there might be a non-linear relationship between banking competition and banking stability.

The heterogeneity test are based on the balanced panel datasets, and the tests results are presented in Table 4.11. To test the heterogeneity among banks, the sample are separated equally into three sub-samples according to their pre-deregulation characteristics. For example, in terms of the bank size measured by total assets, the

[4]The coefficient on the key term *Intra* is estimated to be 0.381 with an standard error of 0.128. Based on the calculation proposed by Kennedy (1981),the percentage effect is estimated to be 45.2%

level I sub-sample only contains small banks with relatively lower total assets, while big banks are categorised into the level III sub-sample, leaving medium sized banks in the level II sub-sample. Then the DID regression is implemented with the same specifications for the three sub-samples separately to show whether the estimated effect of the competition shock varies with the change in bank size.

The first panel in Table 4.11 presents the results from the heterogeneity test on bank size, where bank size is measured by the amount of a bank's total assets immediately before the deregulation. It shows that the estimated coefficient on $Intra$ is only positive and significant for the level I sum-sample, indicating that the intensified competition shock improves the stability of small banks, but has no significant effect on medium-sized and big banks. On the other hand, the estimated coefficient on $Inter$ shows the opposite trend that the stability of big banks tend to be more significantly improved by the intensified inter-state competition, while small banks are unaffected. It indicates that the intra-state competition has a greater impact on smaller banks while inter-state competition is more relevant to big banks. The second panel in Table 4.11 shows that the heterogeneity test on bank size are also conducted with a relative size measurement, though the result is very consistent with that in panel 1.

The third panel in Table 4.11 shows the results from the heterogeneity test on bank profitability. In terms of the intra-state competition, it does not show a clear trend as the estimated coefficients on $Intra$ are significant for both low-profitability banks and high-profitability banks. On the other hand, the result suggests that inter-state competition shock has a greater effect on banks with high profit level as the estimated coefficient on $Inter$ is positive and significant for banks in the level III sub-sample while the estimations for the level I and II sub-sample are not statistically significant.

Table 4.11: Bank-level Result - Heterogeneity Test

	(1)	(2)	(3)
Dependent Variable: $ln(Z_3)$	Level I	Level II	Level III
Absolute Size (total assets)			
Intra	0.050***	-0.016	0.001
	(0.018)	(0.019)	(0.020)
Inter	0.028	0.040*	0.058**
	(0.021)	(0.022)	(0.023)
No. of Banks	2,521	2,522	2,519
Observations	42,851	42,871	42,804
R-squared	0.337	0.315	0.313
Relative Size (total assets/total banking assets in a county)			
Intra	0.024	0.031*	0.015
	(0.021)	(0.018)	(0.018)
Inter	0.017	0.037*	0.056***
	(0.023)	(0.020)	(0.022)
No. of Banks	2,521	2,521	2,520
Observations	42,841	42,846	42,839
R-squared	0.335	0.323	0.312
Profitability (ROA)			
Intra	0.044**	0.009	0.031*
	(0.020)	(0.019)	(0.018)
Inter	-0.016	0.029	0.101***
	(0.024)	(0.021)	(0.020)
No. of Banks	2,520	2,521	2,521
Observations	42,835	42,844	42,847
R-squared	0.315	0.291	0.318
HHI (county level)			
Intra	0.013	0.044**	0.004
	(0.022)	(0.018)	(0.018)
Inter	0.017	0.041**	0.055**
	(0.023)	(0.020)	(0.022)
No. of Banks	2,525	2,518	2,519
Observations	42,922	42,791	42,813
R-squared	0.323	0.330	0.326
Bank Controls	Yes	Yes	Yes
State Controls	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
BEA Region*Year FE	Yes	Yes	Yes

Notes: This table presents the results from the heterogeneity test. To test the heterogeneity among banks, the sample are separated equally into three sub-samples according to their pre-deregulation characteristics. For example, in terms of the bank size measured by total assets, the level I sub-sample only contains small banks with relatively lower total assets, while big banks are categorised into the level III sub-sample, leaving medium sized banks in the level II sub-sample. The first panel presents the results from the heterogeneity test on bank size, where bank size is measured by the amount of a bank's total assets. The results indicate that the intra-state competition has a greater impact on smaller banks while inter-state competition is more relevant to big banks. The second panel shows that the heterogeneity test on bank size are also conducted with a relative size measurement, and the result is very consistent with that in panel 1. The third panel shows the results from the heterogeneity test on bank profitability, which suggests that inter-state competition shock has a greater effect on banks with better profitability. The results from the heterogeneity test on pre-deregulation competition environment is presented by the last panel, where competition is measured by HHI. The results show a clear trend that the inter-state competition shock has a stronger impact on banks operating in a less competitive environment (high HHI). This suggests that there is a non-linear relationship between banking competition and banking stability.

Finally, the results from the heterogeneity test on pre-deregulation competition environment is presented by the last panel in Table 4.11. As it shows, the measurement for competition environment is the Herfindahl-Hirschman Index (HHI) calculated at county level. It shows that the estimated coefficient on $Intra$ are insignificant for both level I and level III banks, indicating that the effect of the intra-state competition shock does not significantly differ due to the different level of competition an individual bank faces. However, the estimated coefficient on $Inter$ across the three subs-samples shows that there is a clear trend that the inter-state competition shock has a stronger impact on banks operating in a less competitive environment (high HHI). This result is consistent with the theoretical predictions by that there is a non-linear effect between banking competition and banking stability (Martinez-Miera and Repullo, 2010; Hakenes and Schnabel, 2011).

4.6 Conclusion

The debate on the relationship between banking competition and financial stability in the literature of financial economics has been on-going for decades since Keeley (1990). This issue has became a particularly important in the aftermath of the global financial crisis erupted in 2008, as the intensive competition in the financial sector before the crisis was seen as one of the main contributors to the collapse of the system.

One strand of literature support the competition-fragility hypothesis that banking competition can destabilise the financial system. It argues that the "charter value" enjoyed by the incumbent banks could be eroded by intensified competition in the system, thus they are likely to take more risks on board and shift the excessive risks towards depositors to maximise their profitability. While in a less competitive environment, incumbent banks tend to have a higher level of profitability which would ultimately contribute to a higher level of capital buffer and better banking stability (Keeley, 1990; Beck et al., 2006; Berger et al., 2009; Beck et al., 2013).

However, the other strand of literature argues that competition in the banking sector can actually improve banking stability. This competition-stability view suggests that the interest rate on lending could be lowered due to banking competition, thus firms and individuals as borrowers may have a lower borrowing cost, which in turn reduces the credit risks faced by the banks. Overall, the stability of the banking system could be improved by banking competition (Schaeck et al., 2009; Anginer et al., 2014). In addition, some also argues that there might exist a non-linear relationship between banking competition and stability (Martinez-Miera and Repullo, 2010; Hakenes and Schnabel, 2011).

The aim of this study is to employ a robust empirical strategy to identify the effect of banking competition on banking stability. Taking advantage of the staggered feature of the U.S. branch banking deregulation in the 1980s, this study implements difference-in-difference (DID) method to address the issue of causality. In sum, it identifies the effect of the intra-state and inter-state competition shock induced by the deregulation policies on banking stability at both state-level and bank-level, where banking stability is measured by Z-score calculated with a 3-year rolling window.

The analysis shows that the intensified competition shock caused by the intra-state branching deregulation significantly improves the state-level banking stability by 45.2%. The result is not only statistically but also economically significant. Meanwhile, it shows that the inter-state branching deregulation is estimated to have no significant impact on banking stability at state-level. This baseline result is confirmed by the dynamic difference-in-difference regressions and also the regressions with alternative stability indicators. The bank-level analysis shows consistent result that the intra-state competition shock has a positive and significant effect on the stability of individual banks, which is also robust with the dynamic DID setting and alternative bank-level stability indicators. However, the scale of the estimated effect at bank-level is much smaller: the intensified intra-state competition just improves the stability of individual banks by 2.12% on average. Overall, these findings provide both state-level and bank-level evidence on the competition-stability hypothesis that banking competition improves banking stability.

The unbalanced feature of the bank-level panel dataset may bias the estimated effect of the competition shock on bank-level stability. To examine this issue, both typical DID and dynamic DID regressions are implemented with a balanced bank-level panel dataset. The results from these regressions are qualitatively unchanged compared with the previous findings from the bank-level analysis. Thus, it confirms that main implication is not driven by the unbalanced observations in the dataset.

Furthermore, it examines the heterogeneity among banks from three perspectives: bank size, bank profitability and the competition environment faced by the bank. It shows that the intra-state competition shock has a greater effect on the stability of small banks, while big banks and more profitable banks are more likely to be affect by the inter-state competition shock. The heterogeneity test also shows that the stability of banks operating in a less competitive environment are more likely to be improved by the inter-state competition shock, which provides evidence on the non-linear relationship between banking competition and stability.

This study also presents opportunities for future work. Though the effect of the competition shock on banking stability is investigated with a variety of stability indicators, such as Z-score, inverse standard deviation of ROA, and non-performing loan ratio, all of these indicators are constructed based on the balance sheet and income statement. The effect could also be examined with stability indicators based on banks' market value. For example, the Distance-to Default is a bank risk measurement proposed by Merton (1974). In addition, as the inter-state branching deregulation is implemented based on state-level reciprocation, the announcement of the implementation of the deregulation might not have a immediate effect. Thus, using a simple dummy variable for the inter-state deregulation based on the year of the announcement may not be able to capture the competition shock properly.

Chapter 5

CONCLUSION

5.1 Summary of Findings

This thesis uses micro-econometric methods to explore factors that could have an impact on banking stability. Based on the European sovereign debt crisis, the first essay aims to answer the following three empirical questions:

1. Can a foreign liquidity shock be transmitted to the domestic banking system through bank ownership linkages?
2. Is there any heterogeneity among banks in transmitting the liquidity shock?
3. Is this transmission more pronounced in developing economies?

To do so, this study constructs cross-border ownership networks for banks located in European countries, and exploits the 2010 European debt crisis as a natural experiment to implement the difference-in-difference (DID) method. The exposure to the liquidity crisis in GIIPS countries is constructed for each international banking group (network) as measured by the proportion of their total banking assets in GIIPS countries.

The baseline results from the DID regressions imply that the subsidiary banks that are highly exposed due to the ownership linkages would significantly reduce their lending during the crisis period, and the magnitude of this negative effect is considerable: if the bank's exposure increases by 1 percent, the bank's lending growth rate would reduce by 5.75 percentage points. This result supports the hypothesis that highly exposed banks' lending performance is negatively affected by the foreign liquidity shock due to the cross-border ownership linkages. Furthermore, it disentangles the transmission channel by exploring the heterogeneity among subsidiary banks in the ownership network. It suggests that larger subsidiary banks and those subsidiaries that were more profitable are found to be more resilient to the shock. It also shows that the parent bank's characteristics affect the transmission of the shock, supporting the notion of an internal capital market operating within these banking groups. The analysis also shows that subsidiary banks located in Eastern Europe are more fragile when facing a external liquidity shock, compared with those located in Western Europe. This implies that subsidiary banks operating in developing countries tend to be more dependent on liquidity support from their parent banks, as the financial sector is usually less developed in developing countries.

The findings from the first essay are directly connected with a strand of literature which focuses on the international transmission of liquidity shocks through bank ownership linkages. For example, Peek and Rosengren (2000) examines whether a liquidity shock in a single country (Japan) could be transmitted into another (United States) while Aiyar (2012) identifies whether the global liquidity shock during the 2008 financial crisis were transmitted to a single country (United Kingdom). In a cross-country setting, Cetorelli and Goldberg (2011) examines whether a liquidity crisis in advanced economies could be transmitted to emerging markets through foreign banks at country level. This essay builds on these papers by providing empirical evidence at the level of the banks and their subsidiaries on the operation of an internal capital market with a cross-country setting. Furthermore, it adds to the literature, by including both developed and developing economies in the sample and testing at the bank level whether bank ownership linkages across Europe can serve as a vehicle to transmit liquidity shock.

The second essay focuses on the effect of sovereign shocks on banks' lending activities through their exposures to the distressed sovereign during the European sovereign debt crisis. More specifically, this essay tries to examine the following three issues:

1. Can a sovereign shock negatively affect banks' lending activity?

2. Through which channel a sovereign shock can destabilise the banking sector?

3. Can the accounting and regulatory treatments of sovereign exposures affect the strength of transmission of the sovereign shock?

Using a rich dataset on banks' sovereign exposures from the European Banking Authority, the analysis also disentangles the transmission channel by breaking down the type and accounting classification of the exposure. In line with previous studies, the analysis shows that negative shocks to sovereign bond are associated to lower subsequent bank lending for banks more exposed to the shocks. Furthermore, it shows that the negative effect of a sovereign shock on bank lending is weaker for better capitalised banks, which provides evidence on the so-called 'capital channel' through which a sovereign shock could be transmitted to banks.

The analysis also shows that bank capital matters especially for exposures that are both mark-to-market and subject to no capital requirements, such as available for sale (AFS) exposures: this seems to be the type of exposure through which sovereign shocks are transmitted directly to bank solvency. The capital channel is less important for book-value exposures (held to maturity) and exposures with positive capital requirements (held for trading). It is also revealed that the capital channel is particularly important for short-term exposures rather than medium- and long-term exposures and that domestic exposures play a more important role in transmitting sovereign shocks compared with foreign exposures.

The findings from the first step analysis in this essay are consistent with the results from the empirical studies in the literature focusing on whether a sovereign shock would have an impact on banks' lending activities (Gennaioli et al., 2014a,b; De Marco, 2015; Popov and Van Horen, 2015). This essay takes a step further from the previous studies, and provides empirical evidence on how exactly a sovereign shock could be transmitted to banks through the 'capital channel' and the 'funding channel'. Further more, this essay also examines the heterogeneity among different types of banks' sovereign exposures with distinctive accounting and regulatory treatment in terms of transmitting sovereign shocks. To my best knowledge, this issues has not been fully explored in the literature. In addition, this essay also contributes to the literature on the effect of the application of fair value accounting in the banking industry where there is no consensus in the literature yet whether fair value accounting could cause excess negative impact on a bank's financial condition.

The third essay explores the relationship between banking competition and banking stability, using the staggered banking deregulation levied by individual states in the U.S. as a natural experiment. Specifically, it identifies the effect of the intensified competition induced by the deregulation on the stability of the U.S. banking sector, and answers the following research questions:

1. Can banking stability be improved by a positive competition shock in the banking sector?

2. Is the effect of banking competition on banking stability non-linear?

3. Is there any heterogeneity among banks in response to a higher level of competition?

The analysis is conducted at state-level as well as bank-level. It shows that the intensified competition shock caused by the intra-state branching deregulation significantly improves the state-level banking stability. Meanwhile, it shows that the inter-state branching deregulation is estimated to have no significant impact on banking stability at state-level. This baseline result is confirmed by the dynamic difference-in-difference regressions and also the regressions with alternative stability indicators. The bank-level analysis shows consistent result that the intra-state competition shock has a positive and significant effect on the stability of individual banks, which is also robust with the dynamic DID setting and alternative bank-level stability indicators. However, the scale of the estimated effect at bank-level is much smaller.

Furthermore, it examines the heterogeneity among banks from three perspectives: bank size, bank profitability and the competition environment faced by the bank. It shows that the intra-state competition shock has a greater effect on the stability of small banks, while big banks and more profitable banks are more likely to be affect by the inter-state competition shock. The heterogeneity test also shows that the stability of banks operating in a less competitive environment are more likely to be improved by the inter-state competition shock, which provides evidence on the non-linear relationship between banking competition and stability.

Overall the contribution of this essays is two fold. First, it exploits the intensified competition in the banking sector induced by the U.S. banking deregulation as an exogenous shock and identifies the the relationship between banking competition and banking stability with a Difference-in-Differences method, instead of GMM exploited by most of the empirical papers in the existing literature. Second, it provides empirical evidence on the non-linear relationship between banking competition and banking stability predicted by a theoretical model proposed by Martinez-Miera and Repullo (2010) and Hakenes and Schnabel (2011), which is a issue that has not been fully investigated in the empirical literature.

5.2 Policy Implications

Several policy implications can be drawn from the analysis in the first essay. First, as a liquidity shock can be transmitted through cross-border bank ownership linkages, regulatory authorities across countries might think carefully about the activities of international banks and whether any of these should be ring fenced. Specific policies targeted at international banks so as to isolate foreign liquidity shocks could help support the stability of a domestic banking system. This is especially important for regulatory authorities in developing countries, as the transmission effect is found to be more pronounced for subsidiary banks located in Eastern Europe. While such regulation may come at an operational cost for the banks involved, this has to be balanced against the need for a stable financial system.

Second, the first essay provides empirical evidence for operation of the internal capital market within banking groups in which international banks allocate their banking assets in order to maximise the profits. Regulators across countries would do better to coordinate their activities and agree policy on an international rather than domestic level. This may help alleviate the potential for contagion across an international bank's internal capital market. Alternatively, supranational institutions for banking supervision should be established to regulate multinational banking groups that operate subsidiary banks across many countries as independent entities. The establishment of the European Banking Authority (EBA) can be a good example as the ultimate regulatory authority of the banking sector in EU countries. The regulatory power across jurisdictions in the EU has been assigned to EBA, and it has been conducting stress tests, capital exercises and transparency exercises since 2010, to assess the banking system of the European Union, using consolidated data for multinational banks across E.U. countries. Similarly, a global-level supranational regulatory authority on banking supervision might be established to better monitor the multinational banks operating subsidiary banks across continents, thus mitigate the contagion effect of the internal capital market within the global bank ownership networks.

The second essay also provides some implications in terms of designing regulatory treatment on banks' sovereign exposures in the macro-prudential policy framework. As it shows, sovereign shocks can be transmitted to banks through banks' exposure to the specific sovereign debt, and capital channel plays a important role in terms of transmitting the shocks. Thus, the current zero risk weight on banks' sovereign exposure to developed countries in the standardised approach might not be prudent. Regulatory authorities may need to increase the risk weight on banks' sovereign exposures to make sure banks can weather sovereign shocks without unduly restricting their lending activity.

More specifically, the risk weight on banks' sovereign exposures should be determined by the particular level of credit risk of the sovereign. For example, the regulatory authorities for the banking sector across European countries might have preferred to put a higher risk weight for banks' exposure to GIIPS countries as the government of GIIPS countries had weaker fundamentals compared with core countries in the EU, such as the U.K. and Germany. The equalised regulatory treatment on banks' exposure to GIIPS debts and those issued by core countries might have encouraged banks in European countries to take more exposure to GIIPS countries, as the literature on the carry trade hypothesis and the moral suasion hypothesis has suggested. A risk-sensitive risk-weighting framework on banks' sovereign exposure maybe essentially helpful in protecting banks from sovereign shocks.

Furthermore, the risk weight on sovereign exposures should be specifically designed according to the accounting classifications of those exposures, as different accounting treatment can cause different economic consequences. For example, a bank's sovereign exposure categorised as available for sale (AFS) assets and those categorised as held to maturity (HTM) assets are both zero risk-weighted. However, a major difference in the accounting treatment between the two types of sovereign exposure is that AFS exposure are marked to market while HTM exposures are accounted for on a historic cost basis. A drop in the market value of the AFS exposure would drive down the bank's capital immediately while the bank's capital is not affected at all if the exposures were categorised as HTM assets. Thus, a higher risk weight might be necessary for sovereign exposures categorised as AFS assets, compared with similar types of exposure categorised in HTM classification, to protect banks' capital against the market risk.

The Basel Committee on Banking Supervision is currently reviewing the regulatory treatment on banks' sovereign exposures, trying to establish a more robust regulatory framework that could better isolate banks from sovereign shocks. Though a risk-sensitive risk-weighting system on sovereign exposures seems to be good option for policy makers, this regulatory tool might be particularly difficult to be implemented as a higher risk weight on sovereigns with weaker fundamentals would reduce their borrowing capacity and increase their funding cost, which would further deteriorate their financial condition. Another concern is that a higher risk weight on banks' sovereign exposure categorised as AFS assets may increase the cost of holding these AFS exposures because they will be required to hold a certain amount of capital against the market risk. As banks generally hold their sovereign exposures in the AFS category as liquidity reserves, a tighter regulatory treatment on AFS sovereign exposures may increase banks' cost of reserving liquidity. Thus, policy makers will have to balance this issue.

The third essay provide evidence on competition-stability hypothesis which suggests that there is a positive relationship between banking competition and financial stability. Thus, regulatory authorities may need to develop policies to facilitate effective competition in the banking sector, along with their prudential policies which are specifically designed to maintain the stability of the financial system, because a relative competitive environment in the banking sector may also improve the overall stability of the financial sector. This is in line with the methodology in the current macro-prudential policy framework in terms of setting capital buffers: globally significantly-important banks (G-SIBs) and domestically significantly-important banks (D-SIBs) need to hold a higher capital buffer on top of their total loss absorbing capacity (TLAC) than small banks. This risk-adjusted and impact-adjusted regulatory capital framework can reduce cost for smaller banks thus enables them to compete with banks with a large market share, which in turn also contributes to improving the stability of the system.

5.3 Limitations and Future Scopes

The analysis in the first essay indicates that subsidiary banks in non-GIIPS countries which are not directly exposed to the liquidity crisis in GIIPS countries would be negatively affected if they are connected with banks located in GIIPS countries through ownership linkages. However, an important caveat to this finding is that those bank's direct exposure to GIIPS government bonds cannot be controlled at subsidiary bank level. While it can control for the bank-specific time-invariant levels of exposure through a bank-fixed effect, it is not possible with the subsidiary bank level data from Bankscope to control for the time-varying exposure to GIIPS debts.

The first essay also presents opportunities for future work. It shows that a liquidity crisis in certain countries (GIIPS) could be transmitted to other countries (non-GIIPS) through the internal capital market within a network of bank ownership. This transmission mechanism is labelled as the 'contagion effect' of the internal capital market. However, given the relatively small number of observations within GIIPS countries and incomplete information on changes in ownership over time, it is unable to identify the support effect of the internal capital market. Therefore, future works can aim to explore this 'support effect' through which the subsidiary banks suffering liquidity shocks in GIIPS countries could be supported by their owners located outside of GIIPS countries.

A common limitation for the first and second essays is that the indicator for the stability of bank lending activity is the total loan growth at bank-level. Using bank-level loan growth data to identify a supply side effect can be imprecise: even though a country-level fixed-effect and other time-varying macroeconomic control variables are used to control for the demand side effect, it is impossible to control for the specific borrowers' demand side effect. Future studies may use more granular information on bank lending, loan-level data for instance, to construct a better indicator for lending stability, so that the borrower-level fixed effect can be introduced to the regressions to rule out the demand side effect to the greatest extent.

The third essay presents avenues for future studies. Though the effect of the competition shock on banking stability is investigated with a variety of stability indicators, such as Z-score, inverse standard deviation of ROA, and non-performing loan ratio, all of these indicators are constructed based on the balance sheet and income statement. The effect could also be examined with stability indicators based on banks' market value. For example, the Distance-to Default is a bank risk measurement proposed by Merton (1974). In addition, as the inter-state branching deregulation is implemented based on state-level reciprocation, the announcement of the implementation of the deregulation might not have a immediate effect. Thus, using a simple dummy variable for the inter-state deregulation based on the year of the announcement may not be able to capture the competition shock properly.

Furthermore, an important caveat to the findings from the third essay is that the empirical setting does not control for the effect of banks' geographical expansion on banking stability. The competition shock in the empirical analysis of the third essay is indicated by dummy variables for the intra- and inter-state branching deregulations. However, previous studies suggest that both types of bank branching deregulations in the U.S. were associated with the geographical diversification in the banking system (Goetz et al., 2013), which in turn would have an impact on banks' risk-taking behaviours (Goetz, 2012). Future studies could control for the geographical diversification channel so that its effect could be isolated from the effect of the increased competition induced by the deregulations on banking stability.

Overall, the analysis of this thesis is based on historic events (eg. European sovereign debt crisis and U.S. Banking deregulation) that could potentially have an effect on banking stability. However, the recent technological innovations and developments in the financial industry have been putting new threats onto the stability of the banking sector. For example, the peer-to-peer (P2P) lending platforms such as Silicon Valley-based Lending Club and London-based Funding Circle have been using data science toolbox to compete with traditional commercial banks on their core banking businesses. The competition from the P2P platforms have further squeezed the interest margin of the traditional banking sector in the post-crisis low interest rate environment. Furthermore, some for-ex focused financial technology firms such as London-based Monzo and Revolut have also reduced banks' fee income from exchanging currencies, which further lowers the profitability of the banking sector. In addition, the rise of the decentralised crypto currencies may also threaten the central position of the traditional banking system in the modern monetary and payment system. Future studies may focus on the impact of these new developments in the financial industry on banking stability.

APPENDIX

Appendix to Chapter 3

Table A3.1: Phase-out Process of the Filters on AFS exposure

		Before 2014	**2014 - 2017**	**2018 onwards**
Proportion of AFS losses included in Common Equity Tier 1 capital	100%	TBC	AT, CY, CZ, DK, EE, FI, FR, GR, HR, LT, LU, LV, MT, RO, SE, SK, UK	All EU member states
	<100%	TBC	BE, BG, DE, ES, HU, IE, IT, NL, PT, SI	

Source: European Banking Authority.

Table A3.2: List of Sample Banks

Country Code	Bank Name
AT	BAWAG P.S.K. Bank fur Arbeit und Wirtschaft und Osterreichische Postsparkasse AG
	Erste Group Bank AG
	Osterreichische Volksbanken AG
BE	Dexia NV
	KBC Group NV
CY	Bank of Cyprus Public Company Ltd
	Hellenic Bank Public Company Ltd
	Marfin Popular Bank Public Co Ltd
DE	Aareal Bank AG
	Bayerische Landesbank
	Commerzbank AG
	Deutsche Bank AG
	HSH Nordbank AG
	Landesbank Baden-Wurttemberg
	Landesbank Berlin Holding AG
	Landesbank Hessen-Thuringen Girozentrale
	Norddeutsche Landesbank-Girozentrale
DK	Danske Bank
	Nykredit
ES	Banca March, S.A.
	Banco Pastor, S.A.
	BFA-Bankia
	Banco Bilbao Vizcaya Argentaria
	Banco Mare Nostrum
	Banco Popular Español
	Banco Santander
	Banco de Sabadell
	Bankinter
	Grupo Banca Civica
	Kutxabank
	Liberbank
	Monte de Piedad y Caja de Ahorros de Ronda, Cadiz, Almeria, Malaga, Antequera y Jaen
FI	OP-Pohjola Group
FR	BNP Paribas
	Groupe BPCE
	Groupe Credit Agricole
	Societe Generale
GR	Agricultural Bank of Greece S.A. (ATEbank)
	Alpha Bank
	Eurobank Ergasias
	National Bank of Greece
	Piraeus Bank
HU	OTP Bank Ltd
IT	Banca Carige S.P.A. - Cassa di Risparmio di Genova e Imperia
	Banca Monte dei Paschi di Siena S.p.A.
	Banca Piccolo Credito Valtellinese
	Banca Popolare Dell'Emilia Romagna - Società Cooperativa
	Banca Popolare Di Milano - Società Cooperativa A Responsabilità Limitata
	Banca Popolare di Sondrio
	Banca Popolare di Vicenza - Società Cooperativa per Azioni

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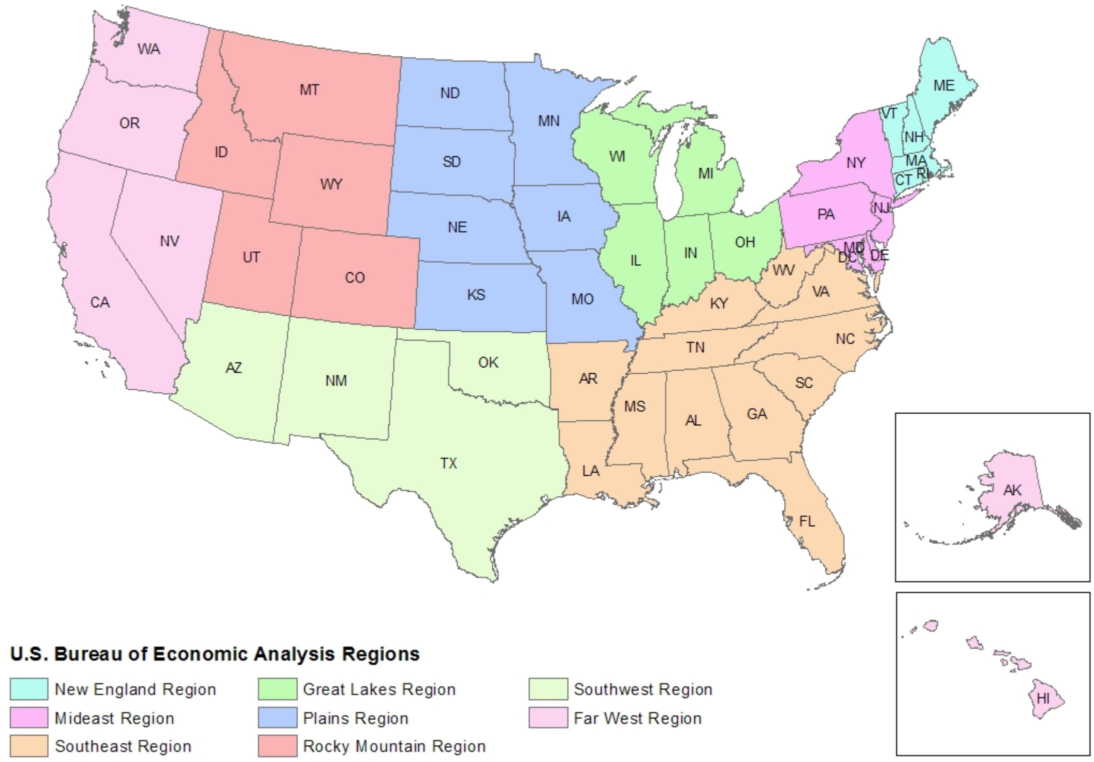
	Banco Popolare - Società Cooperativa Credito Emiliano S.p.A. Mediobanca - Banca di Credito Finanziario S.p.A. UniCredit S.p.A. Unione Di Banche Italiane Società Cooperativa Per Azioni
NL	ABN AMRO Bank N.V. ING Bank N.V.
NO	DNB Bank Group
PL	Alior Bank S.A. Bank BPH S.A. Bank Handlowy w Warszawie S.A. Bank Ochrony Srodowiska S.A. Getin Noble Bank S.A. Powszechna Kasa Oszczednosci Bank Polski S.A. (PKO Bank Polski)
PT	Banco BPI Banco Comercial Português Caixa Geral de Depósitos Espirito Santo Financial Group, SA (ESFG)
SE	Nordea Bank AB (publ) Skandinaviska Enskilda Banken AB (publ) (SEB) Svenska Handelsbanken AB (publ) Swedbank AB (publ)
SI	Nova Kreditna Banka Maribor d.d. Nova Ljubljanska banka d. d.
UK	Barclays plc HSBC Holdings plc Lloyds Banking Group plc Royal Bank of Scotland Group plc

Appendix to Chapter 4

Figure A4.1: U.S. Bureau of Economic Analysis Regions



Source: U.S. Bureau of Economic Analysis
Notes:

Table A4.1: Timing of the U.S. Banking Deregulation

State	Intra-state de novo Deregulation	Intra-state M&A Deregulation	Inter-state Deregulation
Alabama	1990	1981	1987
Alaska	<1970	<1970	1982
Arizona	<1970	<1970	1986
Arkansas	Not deregulated	1994	1989
California	<1970	<1970	1987
Colorado	Not deregulated	1991	1988
Connecticut	1988	1980	1983
Delaware	<1970	<1970	1988
District of Columbia	<1970	<1970	1985
Florida	1988	1988	1985
Georgia	Not deregulated	1983	1985
Hawaii	1986	1986	Not deregulated
Idaho	<1970	<1970	1985
Illinois	1993	1988	1986
Indiana	1991	1989	1986
Iowa	Not deregulated	Not deregulated	1991
Kansas	1990	1987	1992
Kentucky	Not deregulated	1990	1984
Louisiana	1988	1988	1987
Maine	1975	1975	1987
Maryland	<1970	<1970	1985
Massachusetts	1984	1984	1983
Michigan	1988	1987	1986
Minnesota	Not deregulated	1993	1986
Mississippi	1989	1986	1988
Missouri	1990	1990	1986
Montana	Not deregulated	1990	1993
Nebraska	Not deregulated	1985	1990
Nevada	<1970	<1970	1985
New Hampshire	1987	1987	1987
New Jersey	Not deregulated	1977	1986
New Mexico	1991	1991	1989
New York	1976	1976	1982
North Carolina	<1970	<1970	1985
North Dakota	Not deregulated	1987	1991
Ohio	1989	1979	1985
Oklahoma	Not deregulated	1988	1987

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Oregon	1985	1985	1986
Pennsylvania	1990	1982	1986
Rhode Island	<1970	<1970	1984
South Carolina	<1970	<1970	1986
South Dakota	<1970	<1970	1988
Tennessee	1990	1985	1985
Texas	1988	1988	1987
Utah	1981	1981	1984
Vermont	<1970	1970	1988
Virginia	1987	1978	1985
Washington	1985	1985	1987
West Virginia	1987	1987	1988
Wisconsin	1990	1990	1987
Wyoming	Not deregulated	1988	1987

Notes: Data are collected from Amel (1993) and Jayaratne and Strahan (1996). States that are deregulated prior to 1970 are labelled with "<1970" while states that are not deregulated before the sample period ends at 1994 are labelled with "Not deregulated".

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