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Contents

Chapter 1

Introduction

Recent history of many developed and developing countries highlights the importance of two factors for uninterrupted economic growth: first, a main lesson of the financial meltdown of 2007 and 2008 is that systemic exposures in the financial sector can endanger financial stability with large potential costs for taxpayers. Such systemic exposures before and during the global financial crisis were U.S. sub-prime mortgages and heavy reliance on short term whole-sale funding. A second lesson comes from the European sovereign debt crisis. Once the abundance of cheap funding, characterizing the years before 2007, was no longer available and some European sovereigns started to face difficulties in financing their expenditures, a dangerous dynamic started. A weakening of the fiscal position of the sovereign endangered financial stability by making bank defaults more likely (for example through losses suffered by banks on their sovereign debt portfolios), while the necessary recapitalization of some banks put a large burden on government finances, creating a "vicious circle". The second lesson is thus that fiscal policy and financial stability are intertwined.

This dissertation is a collection of essays in these two areas of financial stability. The first part deals with systemic risk in the banking sector. First, it asks whether countercyclical macroprudential policy tools can be an effective way of reducing cyclicality in bank lending. One such tool is the countercyclical capital buffer, which will be soon introduced in Basel III, an international standard of bank regulatory rules. The main finding is that these policies can be counterproductive and may incentivize more intertwined banks, and hence, increase systemic risk. The next paper investigates, and provides some evidence of, the possibility that banks actively change their portfolios in order to influence the likelihood of joint bank failure.

The second part of this dissertation studies the connection between public finance and financial stability. The third paper looks into the interaction between bank capital regulation and taxation and finds that banks trade off leverage risk against portfolio risk in response to higher corporate income tax rates. Finally, the fourth paper analyses banks' excessive holdings of domestic government debt as one of the sources of the interrelated public finance and bank stability. Two possible explanations of banks' home bias are tested: voluntary government bond hoarding as a result of risk shifting and government induced bond buying. In what follows I explain each chapter in more details.

The first paper presents a model in which flat (cycle-independent) capital requirements are undesirable because of shocks to bank capital. There is a rationale for countercyclical capital requirements that impose lower capital demands when aggregate bank capital is low. However, such capital requirements have a cost as they increase systemic risk taking: by insulating banks against aggregate shocks (but not bank-specific ones), they create incentives to invest in correlated activities. As a result, the economy's sensitivity to shocks increases and systemic crises can become more likely. Capital requirements that directly incentivize banks to become less correlated dominate countercyclical policies as they reduce both systemic risk-taking and procyclicality.

The second paper seeks to test a theory of strategic interaction among banks. This theory, the last bank banking theory, asserts that bank decisions are strategic substitutes. This is because healthy banks benefit from the failure of their peers and making different investments and drawing on different funding sources reduces the likelihood of joint failure. I exploit the deregulation of US interstate banking that occurred during the 80s and early 90s to test whether banks choose more heterogeneous loan portfolios and funding strategies in order to reduce the likelihood of joint failure. I find that banks involved in distressed mergers did increase the overall heterogeneity of their business models. Banks achieved this by choosing more diverse asset compositions.

The third paper investigates the interaction between taxation and bank regulation. The tax benefit of interest deductibility encourages debt financing, but regulatory and market constraints create dependency between bank leverage and asset risk. Using a large international sample of banks I find that banks located in high-tax countries have higher leverage and lower average asset risk-weights. I argue that this finding is induced by capital regulation. While the estimated overall effect of taxation on bank risk is modest, it induces significant portfolio reallocation toward less lending. These results suggest that any elimination of the tax bias towards debt may not bring the expected benefits for bank stability.

The fourth paper documents that the largest European banks hold sovereign debt portfolios heavily biased toward their domestic governments. This bias is stronger if (1) both the sovereign and the banks are weak, (2) the sovereign is weak and shareholder rights are strong, and (3) the sovereign is weak and the government has positive ownership in the bank. Furthermore, the home bias is positively valued by the market as reflected by a positive association between the home bias and Tobins q. The home bias premium is small when public finances are weak –keeping bank risk constant, but when both the sovereign and the banks are weak, the premium is positive. These results provide evidence for both the voluntary hoarding and government repression channels of the home bias.

Chapter 2

The Disturbing Interaction between Countercyclical Capital Requirements and Systemic Risk

Abstract We present a model in which flat (cycle-independent) capital requirements are undesirable because of shocks to bank capital. There is a rationale for countercyclical capital requirements that impose lower capital demands when aggregate bank capital is low. However, such capital requirements also have a cost as they increase systemic risk taking: by insulating banks against aggregate shocks (but not bank-specific ones), they create incentives to invest in correlated activities. As a result, the economy's sensitivity to shocks increases and systemic crises can become more likely. Capital requirements that directly incentivize banks to become less correlated dominate countercyclical policies as they reduce both systemic risk-taking and procyclicality.

2.1. Introduction

A key focus of the debate on the design of future financial regulation is on whether the financial system responds efficiently to shocks. While prior to the crisis of 2007-2009 the general view was that the economy adjusts optimally in the advent of shocks, there is a growing consensus that this view is inappropriate when it comes to the financial system. In particular, there is concern that the financial system exacerbates shocks, leading to excessive lending in boom times and sharp contractions in credit when conditions deteriorate. A common explanation for this is that agents in the financial system tend to be subject to constraints that can increase the impact of shocks, such as borrowing constraints that fluctuate with asset prices, risk-sensitive capital requirements or remuneration schemes based on relative performance.

In response to the experience of the recent crisis, there is now a broad move towards policies that mitigate *procyclicality*, the tendency of the financial system to amplify shocks over the cycle. For instance, the new Basel Accord incorporates capital buffers that are built up in good times and can be run down when economic conditions deteriorate. In addition, the liquidity coverage ratio of Basel III – which aims at safeguarding banks against short-term outflows – contains a countercyclical element to the extent that such liquidity buffers are relaxed in bad times. On the accounting side, there is a discussion about whether mark-to-market accounting – which has the potential to amplify the impact of asset price changes – should be suspended when prices are depressed. There is also a growing debate about whether monetary policy should "lean against the wind" with respect to the financial cycle, that is, raise interest rates when the economy experiences excessive credit expansion and asset price inflation, but lower interest rates in times of significant contraction in lending or general stress in the financial system.

In this paper we argue that procyclicality cannot be separated from a second dimension of systemic risk: the extent to which institutions in the financial system are correlated with each other.[1] Such correlation can arise through various channels: herding in investment activities, the use of common funding sources, interconnectedness through interbank linkages, but also through convergence in risk management practices and trading strategies. In particular, we show that there is a two-way interaction between these two dimensions of systemic risk: macroprudential policies that target procyclicality, such as countercyclical capital requirements, affect the correlation of risks in the financial system and correlation (and policies that mitigate it) influence procyclicality. It is thus not possible to address the two dimensions of systemic risk in isolation, which has profound implications for the design of macroprudential regulation.

We consider an economy in which banks face shocks to their capital. There is a role for capital requirements because capital reduces moral hazard at banks (akin to Holmström and Tirole (1997)). Flat capital requirements create a very simple form of procyclicality: when there is a negative shock to bank capital it becomes expensive to fulfill the requirements, reducing welfare by more than the elimination of capital

[1] It is common in the literature to see procyclicality and common risk exposures as the two key – but separate – dimensions of systemic risk (e.g., Borio, 2003).

requirements would. We show that welfare-maximizing capital requirements – for given correlation of risks in the financial system – are countercyclical: when there is sufficient capital in the economy, it is optimal to require banks to hold capital to contain moral hazard, while when capital is scarce it becomes optimal to forego the benefits of capital. Effectively, countercyclical capital requirements increase welfare by mitigating the impact of aggregate shocks to bank capital.

This result no longer holds in general when the correlation of risks is endogenous. We allow banks to choose between a common and a bank-specific project. Since a bank's capital is determined by prior returns on its activities, capital conditions become more correlated when banks invest in the same project. At the same time, correlation makes it also more likely that banks fail jointly. In this case there is a cost as there are no longer sufficient funds in the economy for undertaking productive activities. Banks do not internalize this cost, and hence may choose more correlation than socially optimal.

Countercyclical capital requirements worsen the problem of excessive correlation. The reason is simple: they insulate banks against common shocks, but not against bank-specific ones. The expected cost from exposure to aggregate risk hence falls relative to bank-specific exposures, increasing banks' incentives to invest in the common project. A bank that continues to focus on bank-specific activities would run the risk of receiving a negative shock when aggregate capital is plenty, in which case it would be subject to high capital requirements precisely when it is most costly.

Countercyclical capital requirements thus trade off benefits from reducing the impact of a shock for given exposures in the financial system with higher correlation of risks in the financial system. Their overall welfare implications are hence ambiguous. Perversely, countercyclical policies may even increase the economy's sensitivity to aggregate conditions. The reason is that by inducing banks to become more correlated, they make the financial system more exposed to aggregate shocks, which may result in a greater likelihood of joint bank failures. We show that the appeal of capital requirements that depend on the state of the economy is further reduced when there are commitment problems in capital regulation. This is because a regulator would always face the temptation of lowering capital requirements ex-post when capital is scarce – even though this may not be optimal ex-ante. Carrying out countercyclical policies in a discretionary fashion

– as envisaged by Basel III[2] – can hence induce inefficiencies.

There is an alternative macroprudential policy in our model: a regulator could directly incentivize banks to become less correlated (for example, by charging higher capital requirements for correlated banks). We show that such a policy (if feasible) dominates countercyclical policies. This is because it addresses the two dimensions of systemic risk at the same time: it discourages correlation but also makes the system less procyclical as more heterogenous institutions will respond less strongly to aggregate shocks. In contrast – as discussed before – countercyclical policies improve systemic risk along one dimension at the cost of worsening it along another one.

The key message of our paper is that the two dimensions of systemic risk (common exposures and procyclicality) are inherently linked. The consequence is that policies addressing one risk dimension will also affect the other – and possibly in undesired ways. While our model is set in the specific context of capital requirements and banks, the basic message also applies to other forms of countercyclical policies, such as macroeconomic stabilization policies. For example, a policy of "leaning against the wind" insulates banks against aggregate fluctuations in interest rates[3] and likewise increase incentives for taking on common risk.

Our paper connects two strands of literature. The first investigates whether banking regulation should respond to the economic cycle.[4] Kashyap and Stein (2004) argue that capital requirements that do not depend on economic conditions are suboptimal and suggest that capital charges for a given unit of risk should vary with the scarcity of capital in the economy. Repullo and Suarez (2013) demonstrate that fixed risk-based capital requirements (such as in Basel II) result in procyclical lending. They also show that banks have an incentive to hold pre-cautionary buffers in anticipation of capital shortages – but that these buffers are not effective in containing procyclicality. As a result, introducing a countercyclical element into regulation can be desirable. Malherbe (2013) considers a macroeconomic model where a regulator trades off growth and financial stability and finds that optimal capital requirements depend on business cycle characteristics. Martínez-Miera and Suarez (2012) consider a dynamic model where

[2] See BCBS (2010).

[3] Recent literature also suggests that central banks may want to vary interest rates in an (effectively countercyclical) way in order to reduce the cost of financial crises (e.g., Diamond and Rajan (2011) and Freixas et al. (2011)).

[4] See Galati and Moessner (2011) for a general overview of macroprudential policies.

(fixed) capital requirements reduce banks' incentives to take on aggregate risk (relative to investment in a diversified riskless portfolio). The reason is that capital requirements increase the value of capital to surviving banks in a crisis. This in turn provides banks with incentives to invest in safer activities in order to increase the chance of surviving when other banks are failing (the "last bank standing" effect).

A second strand of the literature analyzes the incentives of banks to correlate with each other. In particular, it has been shown that inefficient correlation may arise from investment choices (e.g., Acharya and Yorulmazer, 2007), diversification (Wagner, 2011; Allen et al., 2012), interbank insurance (Kahn and Santos, 2010) or through herding on the liability side (Segura and Suarez, 2011; Stein, 2012; Farhi and Tirole, 2012). In Acharya and Yorulmazer (2007), regulators cannot commit not to bail out banks if they fail jointly. Anticipating this, banks have an incentive to invest in the same asset in order to increase the likelihood of joint failure. In contrast, the effect in our paper is not driven by commitment problems but arises because there are benefits from letting capital requirements vary with the state of the economy. Another difference to Acharya and Yorulmazer (and most other papers on herding) is that correlation in the banking system – by itself – can be desirable as capital requirements that vary with aggregate conditions then better reflect the individual conditions of banks (by contrast, if bank conditions are largely driven by idiosyncratic factors, varying capital requirements with the aggregate state provides limited benefits). Farhi and Tirole (2012) consider herding in funding choices. They show that when the regulator lacks commitment, bailout expectations provide banks with strategic incentives to increase their sensitivity to market conditions. While in Farhi and Tirole (as well as in Acharya and Yorulmazer (2007)) bank choices are strategic complements, in our setting they are not.

Our paper also relates to the long-standing literature on macroeconomic stabilization policies – as for example analyzed in the context of a textbook IS-LM model. This literature has focused on the ability of stabilization policies in insulating the economy from (aggregate) shocks – taking as exogenous the risk exposures of firms (or banks) in the economy. Since stabilization policies reduce the cost of aggregate shocks in a similar way to countercyclical capital requirements, our analysis suggests that they may also have (potentially unintended) effects by changing the incentives of firms and banks to expose themselves to the aggregate cycle.

The remainder of the paper is organized as follows. Section 2.2 contains the model. Section 2.3 discusses the results. Section 2.4 concludes.

2.2. Model

2.2.1. Preview of the model

We present a simple model in which there is a role for state-dependent capital requirements as well as endogenous systemic risk. The scope for variable capital requirements comes from shocks to bank capital. In particular, a low return on an (existing) project reduces a bank's capital.[5] Since the cost of equity financing is higher than deposit financing in our model, it is costly to use capital as a tool for mitigating moral hazard at the bank. When many banks have low capital, it may then be optimal for the regulator to reduce capital requirements.

Systemic costs arise because when banks fail at the same time, there is a shortage of funds to undertake productive opportunities in the economy. In our model this is because of the existence of a technology that requires a fixed amount of funds.[6] Systemic risk and capital requirements interact because banks can affect the correlation of their projects. In particular, anticipation of capital requirements determines whether banks want to invest in the same project or not. This in turn affects the likelihood of systemic crises, i.e. events when banks jointly fail.

2.2.2. Setup

The economy consists of two bankers, a consumer and a producer. There are three dates $(0, 1, 2)$.

Bankers (denoted with A and B) each have an endowment of one at date 0 and no endowments at the other dates. Bankers derive higher utility from consumption at earlier dates:

$$u^b(c_0^b, c_1^b, c_2^b) = \alpha^2 c_0^b + \alpha c_1^b + c_2^b, \text{ with } \alpha > 1. \tag{2.1}$$

[5] Our view of bank capital is based on Gertler and Kiyotaki (2010), Gertler and Karadi (2011) and Martínez-Miera and Suarez (2012) in that (inside) bank capital derives from accumulated bank profits.

[6] More broadly, systemic costs would arise whenever the economy's production function (or the utility of agents) is convex.

The consumer is endowed with two units of funds at date 0 and has no time preference in consumption:

$$u^c(c_0^c, c_1^c, c_2^c) = c_0^c + c_1^c + c_2^c. \tag{2.2}$$

The producer has no endowment and consumes only at date 2:

$$u^p(c_2^p) = c_2^p. \tag{2.3}$$

At date 0 banker A has access to two projects: an economy-wide project (the "common" project) and a project that is only available to him (the "alternative" project). The project choice is not observable. Banker B has only access to the common project.[7] The returns on the common and the alternative project are independently and identically distributed. Each banker can undertake only one project; we can hence summarize the projects in the economy by C (correlated projects) and U (uncorrelated projects).

A project requires one unit of funds at date 0. At date 1, it returns an amount $\widetilde{x}$, which is uniformly distributed on $[\underline{x}$,$\overline{x}]$ (and hence has a mean of $\mu := \frac{\underline{x}+\overline{x}}{2}$). At this date the banker can also decide to exert effort. Effort increases the expected return on the project at date 2 but comes at a private cost of $z > 0$. At date 2 a project fails with probability p_F, in which case its return is zero. With probability p_H the project reaches a high state and returns R_H ($R_H > 1$). With probability p_L ($p_F + p_L + p_H = 1$) it reaches the low state and returns R_L ($R_L < 1$). If effort had been chosen, the likelihood of the high state increases by $\triangle p$ (> 0) and the one of the low state decreases by $\triangle p$.

The producer has a technology available which at date 2 converts m ($m > 0$) units of funds into $m + \kappa$ ($\kappa > 0$) units. The technology cannot be operated with more or less than m units. There is no storage technology in the economy.

At date 0 the banker has to decide to what extent to (initially) finance the project with own funds, denoted k_0. The remaining financing needs $(1 - k_0)$ can be raised in the form of one-period deposits from the consumer. Deposits are fully insured[8] and the deposit insurance fund is financed by lump sum taxation from the consumer at date 2. At date 1, the deposits mature and the banker decides what amount of it to renew

[7] This is without loss of generality since there is no benefit to having two alternative assets in our economy.

[8] Deposit insurance simplifies the analysis by making the interest on deposits independent of the expected likelihood of project success. It is not the key source of inefficiency in the economy (which is the systemic externality on the producer).

(because of the interim return, he may only partly renew the debt). If he wants to maintain a capital level of k in the bank he pays off $k - k_0$ of debt and consumes the remainder $(x - (k - k_0))$.

There is a regulator who maximizes utilitarian welfare. The regulator sets capital requirements at $t = 1$ (there is no scope for separate capital requirements at $t = 0$). The purpose of capital requirements is to induce efficient effort in the economy. We assume that the return on the common (economy-wide) project is observable (but not the one on the bank-specific project). The regulator can hence condition capital requirements on the return of the common project.[9]

We make the following additional assumptions.

Assumptions

1. $\triangle p(R_H - R_L) > z$,
2. $\triangle p(R_H - 1 + \overline{x}) < z$,
3. $R_L > m$.

Assumption 1) ensures that effort is efficient. Assumption 2) is a condition that will ensure that the interim return (by itself) never suffices to induce effort. Assumption 3 states that the low-state output of a single bank is sufficient to operate the producer's technology.

Timing

The sequence of actions is as follows. At date 0, the regulator announces how date-1 capital requirements will be set depending on the interim return of the common project, x_C. These capital requirements can be summarized by a function $k(x_C)$ (the special case of flat capital requirements arises when k does not depend on x_C). Following this, bank A makes its project choice. After the project choice has been made, banks learn the date-1 interim return of their project x^i and decide on the amount of equity financing k_0^i and raise $d_0^i = 1 - k_0^i$ of deposits. At the end of the period, the consumer and the bankers consume.

[9]This captures that a regulator may be able to set capital requirements based on the state of the economy, but not on the conditions at an individual bank.

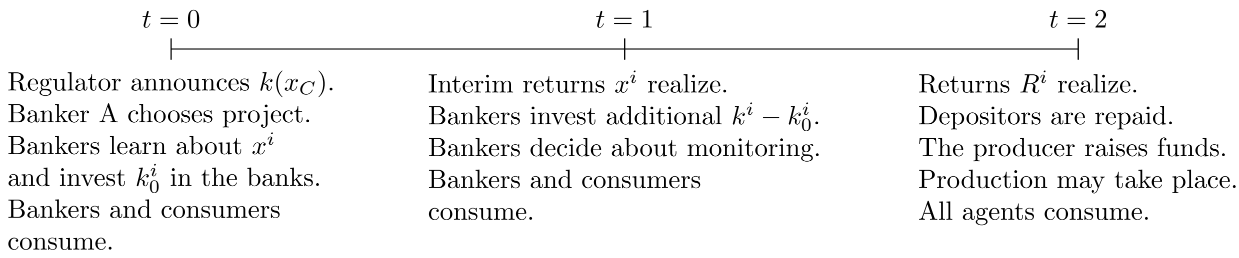


Figure 2.1: Timeline

At date 1, the interim return x^i realizes. Each banker decides how much capital he wants to maintain (k^i), observing the regulatory constraint $k^i \geq k(x_C)$. The banker hence renews an amount $d^i = d_0^i - (k^i - k_0^i)$ of deposits. Following this, banks decide about monitoring their projects and consumption takes place by bankers and the consumer.

At date 2, the returns R^i ($R^i \in \{0, R_L, R_H\}$) realize. Each banker repays the consumer – in case there are sufficient funds. Any shortfall is financed by the deposit insurance fund. Following this, the producer makes an offer to the consumer and/or the bankers for m unit of funds. If he succeeds, the producer operates his technology and repays the funds. In the final stage of date 2, all agents consume. Figure 1 summarizes the timing.

2.2.3. Benchmark: Project choice is observable

To establish a benchmark, we first analyze an economy in which the project choice is observable and can hence be determined by the regulator. The regulator's actions at the beginning of date 0 hence consist of setting capital requirements $k(x_C)$ and the project type for bank A.[10] We solve the model backwards.

At date 2 the producer needs $m > 0$ funds to operate his technology. If the projects of both banks have failed, there are no funds in the economy. The technology can then not be operated and the producer's consumption is hence zero. However, if there is no joint failure, total funds are at least R_L, which is larger than m by Assumption 3. The producer can then raise m units of funds by offering a return of one per unit of funds to the consumer. After operating his technology and repaying the funds, he is left with κ, which he then consumes.

[10] The benchmark is not identical to the constrained-efficient outcome in the economy – a regulator could always resolve the moral hazard problem by allocating the date-1 endowment of the consumer to the bankers.

At the end of date 1, each banker has to make the effort choice. Since a banker's pay-off is $R_H - d^i$ in the high state and $\max\{R_L - d^i, 0\}$ in the low state (as he possibly defaults), the condition that effort is undertaken is

$$\triangle\, p(R_H - d^i - \max\{R_L - d^i, 0\}) \geq z. \tag{2.4}$$

When d^i is such that there is no default in the low state ($d^i \leq R_L$), the effort condition boils down to $\triangle p(R_H - R_L) \geq z$, which is fulfilled by Assumption 1. When there is default in the low state ($d^i > R_L$), we have from (2.4) that the expected benefit from effort is positive whenever capital exceeds a threshold $\overline{k}$, with

$$\bar{k} := \frac{z}{\triangle p} - (R_H - 1). \tag{2.5}$$

In this case the banker will exert effort if and only if $k \geq \bar{k}$.

At the beginning of date 1, a banker has to decide how much capital to maintain in the bank by renewing (a part of the) deposits. The interest rate on deposits is zero because of deposit insurance. The banker has a strict preference for deposit financing over equity financing because he is impatient ($\alpha > 1$) and because deposits are mispriced due to deposit insurance. He will hence only keep the minimum capital required: $k^i = k(x_C)$. He thus does not renew $k - k_0^i$ (we will use from now on k as a shortcut for the rule $k(x_C)$) of the initial amount of deposits and consumes $x^i - (k - k_0^i)$.

At the end of date 0, the banker chooses the amount of own funds (capital) to finance the project. Like at date 1, deposit can be raised at an interest of zero. Given that the banker is impatient, he will only use capital to the extent that is required to fulfill regulatory requirements at date 1. Hence, if $x^i \geq k(x_c)$ (that is, if the date-1 return alone is sufficient to fulfill capital requirements), he will use debt finance only: $k_0^i = 0$. By contrast, if $x^i < k(x_c)$, he will use an amount of capital that, together with the interim return x^i, just allows him to fulfill the capital requirements at date 1: $k_0^i = x^i - k(x_C)$.

The regulator's problem

The regulator maximizes welfare W, consisting of the utilities of bank owners, the consumer and the producer.

We first derive a banker's utility. The consumption of banker i is $1 - k_0^i$ at date 0,

$x^i - (k - k_0^i)$ at date 1 and $\max\{R^i - d^i, 0\}$ at date 2. The banker's total utility is hence $u^{b,i} = \alpha^2(1-k_0^i) + \alpha(k_0^i - (k - x^i)) + \max\{R^i - d^i, 0\} - \mathbf{M}z$, where $\mathbf{M} \in \{0,1\}$ indicates whether effort is exerted. Recalling that $k_0^i = \max(x^i - k(x_C), 0)$ and $k^i = k(x_C)$ (and hence also that $d^i = 1 - k^i = 1 - k(x_C)$) this can be rewritten as

$$u^{b,i} = \alpha^2 - (\alpha^2 - \alpha)\max\left\{k - x^i, 0\right\} - \alpha(k - x^i) + \max\left\{R^i - (1-k), 0\right\} - \mathbf{M}z. \quad (2.6)$$

The utility of the consumer (before contribution to the deposit insurance fund) is simply one as he does not have a time preference and the interest rate is zero. The losses to the deposit insurance fund is $\max\{d^A - R^A, 0) + \max\{d^B - R^B, 0)$. Using $d^A = d^B = 1 - k$, we can write consumer's total utility as

$$u^c = 2 - \max\{1 - k - R^A, 0) - \max\{1 - k - R^B, 0). \quad (2.7)$$

Let us define the *total utility* of a bank as the utility of its banker minus the impact of the bank on the deposit insurance fund. Recalling that the latter is $\max\{d - R, 0\} = \max\{1 - k - R, 0\}$, total utility for a bank of type t is given by

$$u_t^T(k(x_C)) := u_t^b - \max\{1 - k - R_t, 0\}, \quad (2.8)$$

where $t = C$ ($t = U$) indicates that the bank operates a correlated (uncorrelated) project. Taking expectations at date 0 we obtain for the total expected utility:

$$U_t^T(k(x_C)) := \mathrm{E}[\alpha^2 - (\alpha^2 - \alpha)\max\{k - x_t, 0\} - \alpha(k - x_t) + R_t + (k-1) - \mathbf{M}z]. \quad (2.9)$$

The producer consumes κ whenever at least one bank survives, otherwise he obtains zero. His utility is hence

$$c_2^p = \begin{cases} \kappa & \text{if } R^A + R^B > 0, \\ 0 & \text{otherwise.} \end{cases} \quad (2.10)$$

Recalling that the producer obtains κ if at least one bank does not fail, we have for his expected utility in the correlated and the uncorrelated economy:

$$U_C^p = (1 - p_F)\kappa \tag{2.11}$$

$$U_U^p = (1 - p_F^2)\kappa. \tag{2.12}$$

We can write welfare in the economy as the sum of the total (expected) utilities ($U^T(k)$) at the two banks, the consumer's endowment (2) and the producer's utility (U^p). We obtain in the case of a correlated and an uncorrelated economy:

$$W_C(k(x_C)) = 2U_C^T(k) + 2 + (1 - p_F)\kappa \tag{2.13}$$

$$W_U(k(x_C)) = U_C^T(k) + U_U^T(k) + 2 + (1 - p_F^2)\kappa. \tag{2.14}$$

The regulator's problem can then be formalized as $\max_{t\in\{C,U\},k(x_C)} W_t(k)$.

We first solve for the welfare-maximizing policy function, $k^*(x_C)$, for given project choice in the economy (C or U).

Proposition 2.1. *Optimal capital requirements take the form*

$$k^*(x_C) = \begin{cases} \bar{k} & \text{if } x_C \geq \hat{x}^* \\ 0 & \text{otherwise,} \end{cases} \tag{2.15}$$

where $\hat{x}^*$ is given by

$$\hat{x}^* = \begin{cases} \widehat{x}_C = (\frac{1}{\alpha} + 1)\overline{k} - \frac{\triangle p(R_H - R_L) - z}{\alpha^2 - \alpha} & \text{if projects are correlated} \\ \widehat{x}_U = 2\left((\frac{1}{\alpha} + 1)\overline{k} - \frac{\triangle p(R_H - R_L) - z}{\alpha^2 - \alpha}\right) - \mu & \text{if projects are uncorrelated.} \end{cases} \tag{2.16}$$

Proof. Conditional on the effort choice, capital requirements k reduce welfare because of the banker's impatience. When $k \geq x_t$, this is because higher capital requirements require the banker to give up date-0 consumption for date-2 consumption (from equation (2.6) we have for the utility impact: $\frac{\partial u^b}{\partial k} = -\alpha^2$). When $k < x_t$, this is because the banker has to give up date-1 consumption for date-2 consumption (we have then $\frac{\partial u^b}{\partial k} = -\alpha$). It follows that the only benefit of capital requirements is to induce effort. This implies, first, that it is not optimal to set capital requirements such that the bank does not default in the low state (if there is no default, the banker strictly prefers to exert effort by Assumption 1 and capital could be reduced without any cost). We can hence presume default and the effort choice is governed by the critical capital level $\overline{k}$ defined by (2.5). Second, any level of k in the ranges $k \in (0, \overline{k})$ and $k \in (\overline{k}, \infty)$ is also suboptimal, because in these intervals capital can equally be reduced without affecting the effort choice. Thus, the regulator has to consider only two levels of capital requirements: $k = 0$ and $k = \overline{k}$.

We next derive the net (social) benefit from effort at a bank for a given x_C. For this define (equivalently to $U_t^T(k(x_C))$) with $\widetilde{U}_t^T(k(x_C), x_C) = \mathrm{E}[u_t^b - \max\{1 - k - R_t, 0\}|x_C]$ the utility from pay-offs at a bank conditional on x_C. The net benefits from effort are then given by $\widetilde{U}_t^T(\overline{k}, x_C) - \widetilde{U}_t^T(0, x_C)$. Denoting these benefits by $\triangle\widetilde{U}_t^T(x_C)$, we obtain:

$$\triangle\, \widetilde{U}_t^T(x_C) = \triangle p(R_H - R_L) - z - (\alpha^2 - \alpha)(\overline{k} - \mathrm{E}[x_t|x_C]) - (\alpha - 1)\overline{k}. \qquad (2.17)$$

The first two terms ($\triangle p(R_H - R_L) - z$) are simply the benefit from effort in the absence of an incentive problem. The other two terms are the costs of inducing effort through capital requirements. They arise because capital requirements force the banker to shift an amount of consumption $\overline{k}$ from date 1 to date 2, the cost of which is $(\alpha - 1)\overline{k}$. In addition, if the interim return at date 1 is insufficient to fulfill capital requirements ($x_t < \overline{k}$), he also has to give up consumption at date 0. The cost arising from this are $(\alpha^2 - \alpha)(\overline{k} - \mathrm{E}[x_t|x_C])$.

Noting that $\mathrm{E}[x_C|x_C]) = x_C$ and $\mathrm{E}[x_U|x_C]) = \mu$, we can see that the benefits from effort are strictly increasing in x_C for a common project and independent of x_C for an alternative project. Since at least one project in the economy is common, it follows that effort benefits in the economy are always increasing in x_C. Hence, there will be a threshold $\hat{x}$, such that for $x_C \geq \widehat{x}$ it is optimal to set $k = \overline{k}$ and for $x_C < \widehat{x}$ it is optimal to set $k = 0$. When both banks are operating the common project, the policy maker is indifferent to inducing effort when $2 \triangle \widetilde{U}_C^T(\widehat{x}) = 0$. Solving this yields $\widehat{x}_C$. When one project is alternative, the policy maker is indifferent if $\triangle\widetilde{U}_C^T(\widehat{x}) + \triangle\widetilde{U}_U^T = 0$. Solving yields $\widehat{x}_U$. *Q.E.D.*

Proposition 2.1 implies that optimal regulation is countercyclical in the following sense. When the economy is in a good state (that is, when the common project pays off well in the interim), it is optimal to set high capital requirements ($k = \overline{k}$). Conversely, in bad states, it is optimal to set low (zero) capital requirements ($k = 0$).

Corollary 2.1. *Optimal regulation is countercyclical, that is,*

$$Cov(k^*(x_C), x_C) > 0. \tag{2.18}$$

Proof. See appendix.

The intuition for this result is the following. While the benefits from effort are independent of the state of the economy, the cost of inducing effort is higher in bad states. This is because capital at banks is then low (because of low interim returns), making it more costly to induce effort using capital requirements.[11] For sufficiently low capital it becomes then optimal to forego the benefits of effort.

Another implication of Proposition 2.1 is that the critical state of the economy where capital requirements should be lowered depends on the correlation of projects. This has the following consequences for optimal countercyclicality:

Corollary 2.2. *The optimal degree of countercyclicality is lower in the uncorrelated economy unless we are in the special case where μ equals $(\frac{1}{\alpha}+1)\overline{k} - \frac{\triangle p(R_H - R_L) - z}{\alpha^2 - \alpha}$. In this special case, countercyclicality is the same as in the correlated economy.*

Proof. See appendix.

The reason for this result is that while in the correlated economy countercyclical capital requirements lower capital costs at both banks, in the uncorrelated economy they only do so at one bank. The gains from countercyclicality are thus lower in the uncorrelated economy and hence it is optimal to choose a lower degree of it.

Proposition 2.1 states the optimal policy rule for capital for given projects. Whether it is optimal to have correlated or uncorrelated projects in the economy can then be determined by comparing the welfare levels that obtain in either case, presuming that the regulator implements the respective policy rules of Proposition 2.1.

In order to obtain an intuition for the determinants of the optimal project choice, let us presume for a moment that the regulator imposes the same capital requirement rule – characterized by a threshold $\widehat{x} \in (\underline{x}, \overline{x})$ – irrespective of the correlation choice. In

[11]Capital requirements are here more costly in bad states since the pool of capital is then lower. A similar effect would arise if raising capital in bad states is more costly due to a more pronounced adverse selection problem.

this case we obtain from comparing (2.13) and (2.14) that a correlated economy provides higher welfare than an uncorrelated economy if and only if

$$U_C^T(k_{\widehat{x}}(x_C)) - U_U^T(k_{\widehat{x}}(x_C)) > \left(p_F - p_F^2\right)\kappa, \tag{2.19}$$

where $k_{\widehat{x}}(x_C)$ denotes the policy function of the form of equation (2.15) with threshold $\widehat{x}$.

The right-hand side of (2.19) is the expected cost of choosing correlated projects. It arises because there is a higher likelihood of joint bank failure in the correlated economy (p_F instead of p_F^2). Joint failures are costly because the producer can then no longer operate his technology and the surplus κ is lost.

The term $U_C^T(k_{\widehat{x}}(x_C)) - U_U^T(k_{\widehat{x}}(x_C))$ on the left-hand side of (2.19) represents the gains from correlation. These gains arise because in a correlated economy both banks can profit from countercyclical capital requirements (while in the uncorrelated economy only one bank can benefit). Using (2.9) we have that

$$U_C^T(k_{\widehat{x}}(x_C)) - U_U^T(k_{\widehat{x}}(x_C)) = (\alpha^2 - \alpha)\mathrm{E}[\max\{k_{\widehat{x}}(x_C) - x_U, 0\} - \max\{k_{\widehat{x}}(x_C) - x_C, 0\}]. \tag{2.20}$$

For $k = 0$ both terms in the squared brackets are zero, while for $k = \overline{k}$ they are positive (because of Assumption 2). We can hence simplify

$$U_C^T(k_{\widehat{x}}(x_C)) - U_U^T(k_{\widehat{x}}(x_C)) = (\alpha^2 - \alpha)\int_{\widehat{x}}^{\overline{x}} (x_C - \mu)\frac{1}{\overline{x} - \underline{x}}dx_C = (\alpha^2 - \alpha)\frac{\mathrm{Cov}(k_{\widehat{x}}(x_C), x_C)}{\overline{k}}. \tag{2.21}$$

$U_C^T(k_{\widehat{x}}(x_C)) - U_U^T(k_{\widehat{x}}(x_C))$ is hence strictly positive whenever the policy rule is countercyclical ($\mathrm{Cov}(k_{\widehat{x}}(x_C), x_C) > 0$). The reason is that under countercyclical capital requirements common projects have lower costs as such capital requirements tend to be low when capital from common projects is scarce.[12]

When the regulator tailors capital requirements to the correlation choice, additional effects arise because optimal capital requirements depend on correlation in the economy. From equations (2.13) and (2.14) we then have that welfare in the correlated economy

[12] The insight that correlation can be beneficial can be applied to other contexts as well. For instance, a monetary union benefits from its members being similar since interest rates set by the central bank then more easily reflect the individual conditions of the members.

is higher if and only if

$$2U_C^T(k_{\widehat{x}_C}(x_C)) - U_C^T(k_{\widehat{x}_U}(x_C)) - U_U^T(k_{\widehat{x}_U}(x_C)) > (p_F - p_F^2)\kappa. \tag{2.22}$$

From this one can derive Proposition 2.2:

Proposition 2.2. *Correlation is optimal if and only if*

$$(\alpha^2 - \alpha)\frac{\mathrm{Cov}(k_{\widehat{x}_U}, x_C)}{\overline{k}} + 2\int_{\widehat{x}_C}^{\widehat{x}_U} \triangle\widetilde{U}_C^T(x_C)\frac{1}{\overline{x} - \underline{x}}\,\mathrm{d}x_C > (p_F - p_F^2)\kappa. \tag{2.23}$$

Proof. See appendix.

As to be expected, condition (2.23) states that in order for correlated projects to be optimal, the costs of correlation in terms of a higher likelihood of joint failure, $(p_F - p_F^2)\,\kappa$, have to be low. Interestingly, for sufficiently small κ (the cost of a systemic crisis), correlation is always optimal.

2.2.4. Optimal capital requirements when project choice is unobservable

We now assume that the regulator cannot observe the project type. The consequence is that the correlation choice has to be privately optimal for bank A. Specifically, at date 0 the regulator announces the policy rule $k(x_C)$ and bank A chooses a project depending on this policy rule. We constrain the analysis of capital requirements to step functions as in (2.15).

The financing decisions at date 0 and 1 are unchanged. At date 1, a bank will use an amount of equity financing to just fulfill the capital requirements ($k = k(x_C)$), while at date 0 a bank will have equity funding only to cover shortfalls at date 1 ($k_{0,t} = \min\{k(x_C)) - x_t, 0\}$). The effort choices of banks at date 1 are the same as well: a bank monitors if and only if capital requirements are at least $\bar{k}$, as defined in equation (2.5). There is also no change in the behavior of the producer.

This leaves to analyze the project choice of bank A. When deciding in which project to invest, the bank takes as given the policy rule $k_{\widehat{x}}(x_C)$. Writing the expression for banker's utility (equation (2.6)) for a correlated and an uncorrelated project, taking difference and taking expectations at $t = 0$, we obtain the expected gains from choosing the common project (as opposed to the alternative one):

$$U_C^b(k_{\widehat{x}}(x_C)) - U_U^b(k_{\widehat{x}}(x_C)) = (\alpha^2 - \alpha)\mathrm{E}[-\max\{k_{\widehat{x}}(x_C) - x_C, 0\} + \max\{k_{\widehat{x}}(x_C) - x_U, 0\}]. \tag{2.24}$$

Note that equation (2.24) is identical to the total utility difference from pay-offs at the bank (see equation (2.20)) under a fixed policy rule. Using (2.21) we hence have that

$$U_C^b(k_{\widehat{x}}(x_C)) - U_U^b(k_{\widehat{x}}(x_C)) = (\alpha^2 - \alpha)\frac{\mathrm{Cov}(k_{\widehat{x}}(x_C), x_C)}{\bar{k}}. \tag{2.25}$$

Assuming a (weak) preference for uncorrelated projects, we obtain for the correlation choice:

Proposition 2.3. *Banks choose correlated projects if and only if the policy rule is countercyclical ($Cov(k_{\widehat{x}}(x_C), x_C) > 0$).*

Proof. Follows directly from (2.25). *Q.E.D.*

The project choice is, however, not necessarily socially efficient. This is because a banker ignores the impact on the producer – who suffers in the event of joint failure. Since the likelihood of joint failure is higher for correlated projects, choosing the common project is associated with a negative externality.

This will result in an inefficient project choice whenever the policy rule is countercyclical (and bank A hence chooses correlation) but no correlation is welfare-optimal:

Corollary 2.3. *For a given policy rule $k_{\widehat{x}}(x_C)$, banks may choose correlated projects even though no correlation leads to higher welfare. This occurs precisely when $Cov(k_{\widehat{x}}(x_C), x_C) > 0$ and condition (2.23) is not fulfilled.*

It follows that there are situations where the welfare level of the benchmark case can no longer be obtained. In fact, this happens whenever in the benchmark uncorrelated projects are welfare-maximizing. Since welfare-maximizing regulation (in the benchmark case) requires countercyclical capital requirements, banks would find it privately optimal to choose correlated projects, necessarily resulting in lower welfare:

Corollary 2.4. *Whenever condition (2.23) is not fulfilled, attainable welfare is lower than in the benchmark case.*

The regulator's problem

When correlation is optimal in the benchmark case (that is, condition (2.23) is fulfilled), the regulator can still obtain the same level of welfare as before. For this he simply sets (countercyclical) capital requirements to $\widehat{x}_C$ and banks (efficiently) choose correlated projects. In the case where the benchmark stipulates no correlation, we know that we can no longer reach the welfare level of the benchmark case as optimal capital requirements are countercyclical and would hence induce banks to choose correlated projects (Corollary 2.4). This still leaves open what the regulator should do in this case.

Suppose first that the regulator implements correlation in the economy. In this case the regulator is not constrained by banks' private incentives (since banks have a bias towards correlation). The regulator can hence set a threshold identical to the one in the benchmark case: $\widehat{x} = \widehat{x}_C$. Consider next that the regulator wants to implement an uncorrelated economy. In this case, the regulator is constrained by the incentive compatibility constraint of bank A. Proposition 2.3 tells us that he then has to choose a policy that is not countercyclical. Since procyclical policies cannot be optimal, he will hence choose flat (state-independent) capital requirements. This implies that effort is either never or always induced.

Proposition 2.4 derives next the condition for when it is optimal to implement a correlated economy.

Proposition 2.4. *Correlation is optimal when condition (2.23) is met or when*

$$2\left(\int_{\widehat{x}_C}^{\overline{x}} \triangle\widetilde{U}_C^T(x_C)\frac{1}{\overline{x}-\underline{x}}\,\mathrm{d}x_C - \max\{\triangle\widetilde{U}_U^T, 0\}\right) \geq \kappa(p_F - p_F^2). \tag{2.26}$$

The optimal policy rule is then $\widehat{x}_C$. Otherwise, no correlation is optimal and the policy rule is flat and given by

$$\widehat{\widehat{x}}_U = \begin{cases} \underline{x} & \text{if } \triangle\widetilde{U}_U^T > 0, \\ \overline{x} & \text{otherwise.} \end{cases} \tag{2.27}$$

Proof. See appendix.

Note that Proposition 2.4 implies that whenever it is optimal to implement uncorrelated projects, the regulator has to reduce the countercyclicality of capital requirements (compared to the benchmark case).

2.2.5. The role of commitment

We have assumed that at the beginning of date 0, the regulator can commit to a policy rule. In this section we relax this assumption. We assume that the regulator decides on the policy rule at the same time as when projects are chosen. Specifically, the regulator and bank A play Nash at date 0: the regulator maximizes welfare taking the project choice of bank A as given, while banker A maximizes his utility taking the policy function as given.

Consider first a (candidate) equilibrium with correlated projects. In such an equilibrium, the best response of the regulator is $\hat{x}_C$ (since $\hat{x}_C$, by Proposition 2.1, is the optimal policy given that projects are correlated). Since $\hat{x}_C$ is countercyclical, it is also optimal for bank A to choose the common project (Proposition 2.3). Correlation and a policy rule of $\hat{x}_C$ thus form an equilibrium.

Consider next a (candidate) equilibrium with uncorrelated projects. The regulator's best response to an uncorrelated economy is $\hat{x}_U$. However, since this policy is countercyclical, a bank would want to choose the common project. An equilibrium with uncorrelated projects hence cannot exist.

We summarize:

Proposition 2.5. *When the regulator lacks commitment, the unique equilibrium is one with correlated projects and a policy rule of* $\hat{x}_C$.

In the case where no correlation was optimal without commitment problems, welfare is now lower compared to the commitment case. Lack of commitment thus amplifies the cost of countercyclical policies arising from banks' correlation incentives.

2.3. Discussion

In this section we first discuss robustness of several aspects of the model. Following this, we discuss some implications of the model, including for policy.

Funding choices and the interim return. We assumed that banks make funding choices at date 0, knowing the return at date 1. This is not essential for the results. If x becomes known only at date 1, a bank has to use an amount of equity financing at date 0 that is sufficient for fulfilling capital requirements in *all* states of the world at date 1. Countercyclical capital requirements will lower this amount by reducing capital demands in states of the world where the capital stock is low.[13]

Strategic interactions among banks. There is no role for strategic interaction among banks in our model. To see this, consider that bank B also has a project choice. Since the policy rule $k(x_C)$ is set before the project choices, the project choices of bank A and B are not interdependent. Hence, their strategies do not affect each other. Introducing a strategic interaction could either strengthen or weaken the correlation externality. For example, if banks benefit from bail-outs in the event of joint failures (Acharya and Yorulmazer, 2007), this will further increase their correlation incentives. Alternatively, higher correlation among banks can result in interbank externalities by eliminating the possibility for other banks to buy up assets of troubled banks (Wagner, 2011). Such interbank externalities will tend to result in higher correlation than socially optimal. Strategic incentives may also reduce correlation incentives because a surviving bank may enjoy higher benefits when the other bank fails. This may for instance arise because of reduced competition (the "last-bank-standing effect", see Perotti and Suarez, 2002).

Cycle-dependent gains from consumption. We have assumed that the banker's marginal utility at each date is constant, and hence independent of the state of the economy. It is conceivable that in bad (aggregate) states, the marginal utility is higher (because consumption is then lower). This would strengthen the rationale for countercylical policies as it gives rise to an additional reason for lowering capital requirements (which have the effect of reducing consumption of the banker) in downturns.

Cycle-dependent monitoring benefits. In our model the benefit from monitoring is independent of the state of the economy. One may envisage a setting where monitoring is more effective in bad states of the world as assets are then more risky. This effect, if strong enough, could in principle lead to the optimality of procyclical capital requirements. In this case there would no longer be a trade-off between effort provision and correlation

[13]For a correlated bank, the capital needed to be transferred to date 1 is $\max_{x_C \in [\underline{x}, \overline{x}]}\{k(x_c) - x_C\}$. For larger $Cov\{k(x_c), x_C)$ (that is, larger countercyclality), this expression will tend to be smaller.

incentives.

Deposit insurance. Assuming the presence of a deposit insurance system has simplified the analysis but is not crucial for the results. In the absence of deposit insurance, there is no need for regulators to impose capital requirements for the purpose of inducing efficient effort. Rather, depositors themselves can require bankers to hold certain levels of capital at date 1 (if contractionally feasible). However, such capital requirements will not be socially efficient because they do not address the externality on the producer (there will still be a tendency for inefficiently high correlation in the economy). Hence a rationale for regulation of capital at banks remains. The determination of optimal capital requirement will then be subject to the same trade-off as in the model (efficient effort versus systemic risk-taking).

Systemic externality. Our assumption that the producer can extract the full surplus on production is an extreme one. For the externality to hold, however, it is only important that banks (individually) can not extract the full surplus. In principle, the technology could also be operated by one of the banks. The externality would then become an interbank externality. This is because one bank would ignore that if it decides to become correlated with the other bank it reduces the likelihood that the other banks has sufficient resources to carry out the project.[14]

Interbank markets. The capital endowments of banks can differ at date 1. Nevertheless, there are no gains from trade and hence no scope for interbank markets where banks can borrow and lend to each other. This is because addressing the moral hazard problem requires *inside* equity, funds obtained from the other bank cannot improve incentives.

Bank-specific capital requirements. The cost of countercyclical policies (in the form of higher correlation) could be avoided entirely if capital requirements can be made contingent on bank's individual project returns (x^A and x^B) instead of the return on the common project only (as we have assumed). In this case regulators can isolate each bank against shocks to its own capital, and there is hence no longer an incentive to increase exposure to common risk. However, such capital requirements do not seem attractive for

[14]Calculations available on request from the authors.

several reasons. First, they have high informational requirements as the regulator then needs to observe individual bank conditions. Second, there are issues of inequality and competition as weaker banks would be subjected to less stringent regulation. Third, it creates obvious moral hazard problems to the extent that banks can influence the return on their projects.

Reducing procyclicality versus reducing cross-sectional risk. Our model suggests that if tools are available that can directly influence the correlation choices of banks,[15] they are to be preferred over countercyclical measures. This is because reducing correlation has two benefits. First, it lowers the likelihood of a systemic crisis (joint bank failure) and the costs associated with it. Second, it lowers the sensitivity of bank capital to shocks (the volatility of aggregate bank capital is lower in the uncorrelated economy), reducing the need for countercyclical policies.

Countercyclical capital requirements, in contrast, have the cost of increasing correlation risk – as we have shown. Perversely, they can even increase the sensitivity of the economy to aggregate conditions. To see this, consider that starting from flat capital requirements, the regulator (marginally) increases countercyclicality. The economy will then move from an uncorrelated to a correlated equilibrium (Proposition 2.3). This will increase the likelihood of joint failures but also increase the sensitivity of aggregate bank capital to shocks. The latter occurs because shocks now affect both banks equally – while the (marginal) increase in countercyclicality will only have a second-order effect.

Managerial herding. The mechanism that leads to higher correlation in our model (arising because countercyclical policies reduce expected capital costs at banks) is only one of the many possible ways this may happen. For instance, countercyclical policies may also be conducive to herding by bank managers. This is because such policies make it more likely that following alternative strategies results in underperformance relative to peers as the manager then cannot benefit from the smoothing of shocks enjoyed by other banks that expose themselves predominantly to aggregate shocks.

[15]Examples of such tools include capital requirements based on measures of banks' systemic importance, such as the CoVar (Adrian and Brunnermeier, 2011) or the Systemic Expected Shortfall (Acharya et al., 2012).

Countercyclical policies in developing countries. Our analysis suggests a positive relation between the extent to which regulators use macroprudential tools to offset economic fluctuations and the extent to which banks correlate with each other. While with the exception of Spain, capital requirements have not been consistently used for macroprudential purposes, Federico et al. (2012) show that many developing countries have made active use of reserve requirements over the business cycle. Defining countercyclicality as the correlation of reserve requirements with GDP, they find that the majority of these countries used reserve requirements in a countercyclical fashion.

Figure 2.2 plots their measure of countercyclicality against the average pairwise correlation of banks in the respective countries.[16] Consistent with the predictions of our model, we can indeed observe a positive relationship between countercyclicality and bank correlation: the correlation coefficient is 0.38 (albeit insignificant due to the small number of observations).

2.4. Conclusion

We have developed a simple model in which there is a rationale for regulation in reducing the impact of shocks on the financial system. In addition, in this model aggregate risk is endogenous since banks can influence the extent to which they correlate with each other. We have shown that countercyclical macroprudential capital requirements – while reducing the impact of shocks on the economy ex-post – provide banks with incentives to become more correlated ex-ante. This is because such capital requirements lower a bank's cost from exposure to aggregate risk – but not the cost arising from taking on idiosyncratic risks. The overall welfare implications of countercyclical policies are hence ambiguous.

Our results have important consequences for the design of macroprudential policies. First, policy makers typically view different macroprudential tools in isolation: there are separate policies for dealing with procyclicality (e.g., countercyclical capital buffers) and correlation risk (e.g., higher capital charges for Systemically Important Financial Institutions as under Basel III). Our analysis suggests that there are important interactions

[16] Correlations are calculated based on the weekly stock returns of all listed banks in the year prior to September 2012. Six countries had to be dropped due to an insufficient number of listed banks.

among these tools. In particular, policies that mitigate correlation are a substitute for countercyclical policies since lowering correlation also means less procyclicality (while the reverse is not true). This suggests that if regulators prefer to employ a single policy instrument (for political or for practical reasons), they should focus on reducing cross-sectional risk rather than on implementing countercyclical measures.

Second, Basel III envisages countercyclical capital buffers that are imposed when (national) regulators deem credit expansion in their country excessive.[17] Such discretionary buffers create a new time-inconsistency problem since a regulator will always be tempted to lower capital requirements in bad times, while it will be difficult for regulators to withstand pressure and raise capital requirements in boom times. Our analysis suggests in that context that providing domestic regulators with the option to modify capital requirements during the cycle may be counterproductive for the objective of containing systemic risk as it may increase banks' correlation incentives.

Finally, while our model considers capital requirements as a policy tool, any alternative policy that smooths the impact of aggregate shocks will likewise suffer from the problem that it increases correlation incentives in the economy. Our argument hence applies to a wide range of policies, ranging from countercyclical liquidity and reserve requirements, suspension of mark-to-market pricing in times of stress to general macroeconomic stabilization policies (such as "leaning against the wind" by the central bank).

[17]BCBS (2010) and Drehmann et al. (2011) recommend the buffer be linked to the gap between the credit-to-GDP ratio of a country and its trend. Repullo and Saurina (2011) warn that overreliance on such measures can lead to increased procyclicality because of imperfections in the credit-to-GDP gap measure.

2.5. Appendix

Proof of Corollary 2.1. We have that $Cov(k^*(x_C), x_C) = \int_{\underline{x}}^{\overline{x}} (k^*(x_C) - E[k^*(x_C)])(x_C - \mu)\frac{1}{\overline{x}-\underline{x}} dx_C$, which can be simplified to $Cov(k^*(x_C), x_C) = \overline{k} \int_{\widehat{x}^*}^{\overline{x}} (x_C - \mu)\frac{1}{\overline{x}-\underline{x}} dx_C = \frac{\overline{k}}{4}\frac{(\overline{x}-\widehat{x}^*)(\widehat{x}^*-\underline{x})}{\overline{x}-\underline{x}} > 0$ for $\widehat{x}^* \in (\underline{x}, \overline{x})$. *Q.E.D.*

Proof of Corollary 2.2. From $Cov(k^*(x_C), x_C) = \frac{\overline{k}}{4}\frac{(\overline{x}-\widehat{x}^*)(\widehat{x}^*-\underline{x})}{\overline{x}-\underline{x}}$ (see proof of Corollary 2.1) we have that the covariance attains its minimum at $\hat{x} = \frac{\underline{x}+\overline{x}}{2} = \mu$ and is a monotonous function on the intervals $[\underline{x}, \mu]$ and $[\mu, \overline{x}]$. The corollary then follows from the fact that for $\hat{x}_C < \mu$ we have $\hat{x}_U < \hat{x}_C$ and that for $\hat{x}_C > \mu$ we have $\hat{x}_U > \hat{x}_C$. *Q.E.D.*

Proof of Proposition 2.2. If $\widehat{x}_C > \mu$ (and hence $\widehat{x}_C < \widehat{x}_U$ since we have $\widehat{x}_U = 2\widehat{x}_C - \mu$ by equation (2.16)) we obtain

$$U_C^T(k_{\widehat{x}_C}(x_C)) = U_C^T(k_{\widehat{x}_U}(x_C)) + \int_{\widehat{x}_C}^{\widehat{x}_U} \triangle\widetilde{U}_C^T(x_C)\frac{1}{\overline{x}-\underline{x}}\,\mathrm{d}x_C. \tag{2.28}$$

Using in addition equation (2.21) (written for $\widehat{x} = \widehat{x}_U$) to substitute $U_C^T(k_{\widehat{x}_U}(x_C)) - U_U^T(k_{\widehat{x}_U}(x_C))$, we can rewrite equation (2.22) as

$$(\alpha^2 - \alpha)\frac{\mathrm{Cov}(k_{\widehat{x}_U}, x_C)}{\overline{k}} + 2\int_{\widehat{x}_C}^{\widehat{x}_U} \triangle\widetilde{U}_C^T(x_C)\frac{1}{\overline{x}-\underline{x}}\,\mathrm{d}x_C > (p_F - p_F^2)\kappa. \tag{2.29}$$

Similarly, if $\widehat{x}_C < \mu$ (and hence $\widehat{x}_C > \widehat{x}_U$), we can rewrite equation (2.22) as

$$(\alpha^2 - \alpha)\frac{\mathrm{Cov}(k_{\widehat{x}_U}, x_C)}{\overline{k}} - 2\int_{\widehat{x}_U}^{\widehat{x}_C} \triangle\widetilde{U}_C^T(x_C)\frac{1}{\overline{x}-\underline{x}}\,\mathrm{d}x_C > (p_F - p_F^2)\kappa. \tag{2.30}$$

Combining (2.29) and (2.30) gives (2.23). *Q.E.D.*

Proof of Proposition 2.4. The optimality of correlation when condition (2.23) is fulfilled (that is, correlation is optimal in the benchmark case) is obvious as then the incentive constraint of bank A is irrelevant. Consider next that condition (2.23) is not fulfilled.

If the regulator wants to implement correlation, he is still not constrained by the incentive constraint of bank A, and can hence choose the same policy as in the benchmark case: $\widehat{x} = \widehat{x}_C$. If he wants to implement an uncorrelated outcome, he has to choose a policy that is either procyclical or flat. Procyclical policies are always dominated by flat policies as the former require higher capital when capital is scarce but have no benefits.

The regulator hence chooses a flat policy, of which there are two: either he always sets $k = 0$ (that is, a threshold of $\widehat{x} = \underline{x}$) or $k = \overline{k}$ (that is, a threshold of $\widehat{x} = \overline{x}$). Which of the two dominates depends on whether in expectation it is beneficial to always induce effort or not, that is, on the sign of $E[\triangle\widetilde{U}_C^T(x_C)] + E[\triangle\widetilde{U}_U^T(x_C)] = \triangle\widetilde{U}_C^T(\mu) + \triangle\widetilde{U}_U^T = 2\triangle\widetilde{U}_U^T$. If $\triangle\widetilde{U}_U^T > 0$, then setting $k = \overline{k}$ is optimal, otherwise $k = 0$ is optimal.

In order to determine whether correlation is optimal, we have to compare welfare for the threshold $\widehat{x}_C$ (correlation) with welfare under the two flat capital requirements (no correlation). Thus, we have to compare $W_C(k_{\widehat{x}_C}(x_C))$ with the maximum of $W_U(k_{\underline{x}}(x_C))$ and $W_U(k_{\overline{x}}(x_C))$. The three respective welfare levels are given by:

$$W_C(k_{\widehat{x}_C}(x_C)) = 2(\alpha + \mu + p_H R_H + p_L R_L) + 2\int_{\widehat{x}_C}^{\overline{x}} \triangle\widetilde{U}_C^T(x_C)\frac{1}{\overline{x} - \underline{x}}\,\mathrm{d}x_C - p_F\kappa \quad (2.31)$$

$$W_U(k_{\underline{x}}(x_C) = 2(\alpha + \mu + p_H R_H + p_L R_L) - p_F^2\kappa \quad (2.32)$$

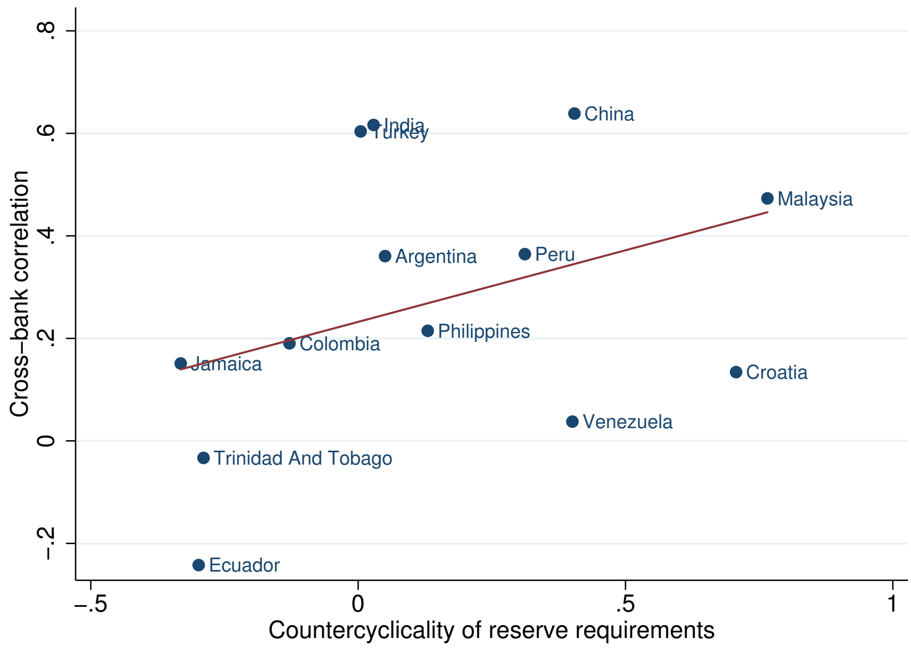
$$W_U(k_{\overline{x}}(x_C) = 2(\alpha + \mu + p_H R_H + p_L R_L) + 2\triangle\widetilde{U}_U^T - p_F^2\kappa. \quad (2.33)$$

Rearranging $W_C(k_{\widehat{x}_C}(x_C)) > \max\{W_U(k_{\underline{x}}(x_C)), W_U(k_{\overline{x}}(x_C))\}$ using (2.31)-(2.33) yields (2.26). *Q.E.D.*

2.6. Figures

Figure 2.2: The relationship between the countercyclicality of reserve requirements and cross-bank correlation

Countercyclicality of reserve requirements is the correlation between the cyclical component of reserve requirements and real GDP (source: Federico et al. (2012)). Cross-bank correlation is the average pairwise correlation of banks using weekly stock returns from September 2011 to September 2012.



Chapter 3

Bank Heterogeneity and Mergers: Evidence Using the Deregulation of US Inter-state Banking Restrictions

Abstract This paper seeks to test a theory of strategic interaction among banks. This theory, the last bank banking theory, asserts that bank decisions are strategic substitutes. This is because healthy banks benefit from the failure of their peers and making different investment and funding decisions reduces the likelihood of joint failure. I exploit the deregulation of US interstate banking that occurred during the 80s and early 90s to test whether banks choose more heterogeneous loan portfolios and funding strategies in order to reduce the likelihood of joint failure. I find that banks involved in distressed mergers did increase the overall heterogeneity of their business models. Banks achieved this by choosing more diverse asset compositions.

3.1. Introduction

In the years after the latest financial crisis, which revealed a large systemic exposure in the financial sector, understandably a lot of attention is focused on the reasons of high interrelatedness among banks. Less attention is payed to the incentives for banks to choose uncorrelated strategies and to become resistant to systemic shocks. On one side of the table are theoretical models and a growing empirical literature that finds that banks do indeed herd, and that large banks exploit implicit bailout guarantees, which all increase systemic risk.

On the other side are a few papers that argue that banks also have a reason to try to survive systemic crises, because that offers them rents once a shock hits. The last bank standing channel put forth by Perotti and Suarez (2002) and Martínez-Miera and Suarez (2012) postulates that increased market power and/or scarcity rents of capital following the failure of competing banks induces at least some banks to try to survive the failure of their peers. This paper seeks to find evidence for the last bank standing channel using the elimination of cross-state bank merger restrictions in the United States as the source of exogenous variation.

Prior to the mid 70's most states in the US had state laws forbidding out-of-state banks to enter their local markets. Beginning with the mid 1970s, however, several states passed bills permitting the acquisition of in-state banks by banks chartered in a different state. This state-by-state process culminated in the passing of a federal law, the 1994 Riegle-Neal Interstate Banking and Branching Efficiency Act, which came into force in 1997, eliminating almost all restrictions on cross-state banking acquisitions.

This policy change affected the incentives of banks vis-à-vis other banks in the same state differently from banks across states. Based on this observation I estimate a difference-in-difference model to explore whether the balance sheets of affected bank-pairs diverged over time relative to the balance sheets of unaffected banks, consistent with the prediction of the last bank standing channel. While cross-state banking restrictions existed banks chartered in one state were not permitted to open branches or acquire the assets of banks in states other than their own. This implies that banks had no incentives to strategically interact with banks chartered in other states. After the lifting of the restrictions, however, the expected failure of some banks might have created potential gains for other banks – irrespective of being located in the same state or not. Because these benefits could only be realized by solvent, healthy banks, the last bank standing channel predicts that banks changed their business models relative to their cross-state peers after deregulation to reduce the likelihood of joint distress. In contrast, banks are not expected to have changed their business models compared to their peers within the same state, and can thus serve as a control group.

The basic approach of this paper is a difference-in-difference estimation, where I compare the balance sheets of pairs of banks located across and within states, before and after deregulation. I measure balance sheet differences using a measure similar to that employed by Cai et al. (2011). I also account for the possibility that some banks follow a herding strategy. Since this decision is unobservable, I proxy banks' decision to try to be last banks standing by being involved in distressed mergers. Distressed mergers are mergers that involved regulatory intervention and often result in arrangements that compensate the buyer for future losses suffered on the acquired assets, thus making the deals more attractive to shareholders. Finally, using non-distressed mergers helps control for different time trends between cross-state and intra-state bank pairs. The baseline model of the paper is thus a difference in double-difference model: a difference over time, between cross-state and within-state, and distressed and non-distressed mergers.

The main finding of this paper is that the dissimilarity between balance sheets of banks later involved in distressed mergers increased after deregulation for banks located in different states, relative to same-state bank pairs and banks involved in non-distressed mergers. Additionally, I also show that the variable I use to measure balance sheet differences predicts distressed mergers, i.e. two banks are more likely to merge in a distressed merger (both relative to non-merging banks and banks that merge without regulatory involvement) if they had more different balance sheets ex ante. I rule out several sources of potential biases. Firstly, restricting the sample to mergers creates static selection bias. I control for this bias by including merger fixed effects. Second, the difference-in-difference approach controls for the apparent concern that bank heterogeneity influences the likelihood of mergers and the risk of interpreting the causality of results in the wrong way. Third, I exclude a long period before the date of mergers to mitigate the possibility that negative shocks and slow adjustment lead to the acquisition of failing banks and simultaneously increase the heterogeneity measure.

These results are consistent with an endogenous choice of banks to choose an asset and liability mix that increases the probability that they acquire banks in distress, or alternatively, that they are acquired when they are facing bankruptcy. In additional tests I find that deregulation had an impact especially in states that removed cross-state banking restrictions relatively early. More precisely, I find a significant relative increase in the difference between the balance sheets of banks involved in cross-state, distressed mergers in states that deregulated before 1986. In turn, I do not detect a significant change in the sample of mergers involving banks in states that deregulated after 1986. This suggests that banks did not anticipate the first wave of deregulation, unlike the removal of the restrictions in states that deregulated relatively late, which allowed them to adjust their balance sheets before the new rules took effect. Alternatively, it is also possible that the relative benefits of being last bank standing decreased over time. In an additional test I exclude mergers that occurred after 2006 and I find even stronger effects consistent with the last bank standing channel. This evidence is also consistent with declining benefits of business model diversity over the last decades in the US, however, an alternative explanation is that distressed mergers in the far future are less precise proxies of banks' decision to choose a last bank standing strategy.

These results have implications for competition policy and bank regulation. Firstly, there is only limited evidence on strategic interaction among banks and how this depends on the likelihood of joint bank failures (Bonfim and Kim, 2012; Jain and Gupta, 1987). My results suggest that banks respond to changes in their payoffs in systemic crises by changing their systemic exposures. The changes in their payoffs can be a result of various policies, such as liquidity provisioning (Farhi and Tirole, 2012), countercyclical capital requirements (Horváth and Wagner, 2013; Repullo and Suarez, 2013) or other macro macroprudential tools, such as Pigovian taxes (Perotti and Suarez, 2011). Secondly, the results show how competition and merger policy interact with bank regulation. A very restrictive merger policy may have a negative effect on systemic risk by weakening the last bank standing channel. Similarly, a fully competitive market may not only exacerbate banks' individual risk shifting problem, but may also create more systemic risk. An optimal policy should therefore balance the risk benefits of bank mergers through the last bank standing channel and contained competition with the social costs of reduced competition.

This paper relates to several strands of literature. There are several papers analyzing bank consolidation following deregulation in the US. For instance, Wheelock and Wilson (2000) investigate the determinants of US bank failures and acquisitions. They find that less efficient banks are more likely to fail and banks closer to insolvency are more likely to be acquired. This paper shows that even if ex ante banks have the same amount of insolvency risk, heterogeneity may arise across banks, because banks can endogenously choose states of the world in which they approach insolvency.

There is a substantial amount of work done on the relationship between bank efficiency and geography. Berger and DeYoung (2001) find that geographic distance has a negative effect on bank performance, although the authors argue that this effect is modest and that some banks may efficiently operate in geographically dispersed multi-bank holding company structure, while for others a single-market operation is optimal. Uysal et al. (2008) on the other hand find that local mergers (within a geographic distance of 100km) offer significantly larger gains than distant ones and argue that information advantages facilitate the acquisition of local targets. Ferrier and Yeager (2007) find that local mergers enhance performance within bank holding companies and reduce efficiency outside BHCs. It appears thus, that while geographic proximity is beneficial for bank post-merger performance, cross-state bank mergers may also provide benefits. Indeed, I also find that while most mergers in the sample happen locally, there was a significant amount of cross-border merger activity after deregulation.

A closely related paper is Goetz et al. (2013) who estimate the effect of geographic diversification of bank holding company assets across the US on their market valuations. The authors, like this paper, exploit the process of interstate banking deregulation for identification purposes and find that an exogenous increase in bank diversification reduces bank valuation. This effect should reduce banks' incentives to engage in cross-state banking to the extent that it results in more geographic complexity within the banking organization. My results suggests that the valuation reducing effect of this channel was dominated by the gains of mergers possibly by avoiding bankruptcy costs.

There is a vast literature on the mergers of banks and more generally, non-financial firms. The literature mostly agrees that on average acquiring banks experience a reduction in bank valuation (either as seen from stock price changes as in Lobue (1984), Desai and Stover (1985), James and Weir (1987); Neely (1987); Trifts and Scanlon (1987) or DeLong (2001a) or by inferring from declining performance measures post merger as in Rhoades (1986, 1990, 1993, and 1997), Spindt and Tarhan (1992), Linder and Crane (1993), Peristiani (1993), or Rose (1987)), while target banks gain from the merger. There is also evidence, however, that there is substantial heterogeneity in mergers and some characteristics make it more likely that the acquirer benefits from the transaction (Houston and Ryngaert, 1994; Al-Khasawneh and Essaddam, 2012). However, these studies do not investigate returns to acquirers and targets in distressed bank mergers, which to my knowledge is unchartered area.

There is, albeit, evidence on the valuation effects of mergers in other industries. Clark and Ofek (1994) find no evidence of successful restructuring through mergers using a sample of 38 mergers. Using larger samples, however, several papers find that when the assets of bankrupt or distressed firms are acquired, the acquiring firms experience positive valuation effects (Bartunek et al., 1995; Hotchkiss and Mooradian, 1998; Jory and Madura, 2009) as do target firms (Hotchkiss and Mooradian, 1997). Jory and Madura (2009) also find that the positive valuation effects are especially large when the acquiring firm is in the same industry as the target firm. This evidence suggests, that there might be gains from the acquisition of distressed banks, to be reaped by either the acquirer or the target bank, or both.

I proceed in Section 3.2 by introducing the origins and history of US inter-state banking restrictions. Section 3.3 discusses the hypotheses and the econometric approach. Section 3.4 describes the data used in this study, and Section 3.5 presents the results of the difference-in-difference model. Section 3.6 provides evidence of the appropriateness of the bank balance sheet heterogeneity measures. I conclude in Section 3.7.

3.2. An overview of the history of US interstate banking deregulation

Kroszner and Strahan (1999) provide a detailed overview of the origins of the interstate banking restrictions and the process of their dismantling. The authors relate the origins of the restrictions to the inability of states to freely issue fiat money and taxing interstate commerce. States derived a sizable portion of their revenues from charter license fees paid by banks. Since banks chartered in other states were exempt from paying such fees, each state had an inherent interest in preventing their domestic banking sector from competition by cross-state banks so as to maximize revenue from local banks. Some states restricted even intra-state branching, which prevented banks with several banking units to set up a unified operation, including a common back-office. Each banking unit of a multi-bank holding company essentially represented a separate bank, each having to meet regulatory standards on a stand-alone basis.

Until the early 1970s most US states had restrictions on intra-state branching as well as interstate banking. Between about 1970 and 1992 almost all states removed these restrictions in a sequential process. This happened on a bilateral basis: states passed laws allowing banks chartered in other states to acquire banks in their jurisdiction if the host state passed a similar law. The first such law was passed by Maine in 1975 allowing out-of-state banks to acquire in-state Maine banks starting 1978. After that many states entered into reciprocal arrangements, by 1992 most states had some arrangement allowing inter-state banking.

This process culminated with a national law, the 1994 Riegle-Neal Interstate Banking and Branching Efficiency Act, which effectively removed all restrictions on inter-state banking at the national level. The Act came into force in 1997. Interestingly, federal legislators amended the Bank Holding Company Act in 1982 as part of the Garn-St Germain Act, after which failed banks and thrifts could be acquired by any bank holding company, regardless of any state regulation. This does not affect my analysis, since the sample excludes bank holding companies.[18]

It is essential for the identification strategy in this paper that deregulation be exogenous with respect to bank heterogeneity. Several papers investigate the origins of the restrictions and the drivers of deregulation. Economides et al. (1995) show that small banks lobbied for general deposit insurance and strict branching restrictions in order to protect themselves from competition by larger, more efficient banks. The lobbying power of small banks proved strong over the decades before deregulation took off as suggested by White (1998), who shows that small banks successfully lobbied to increase deposit insurance limits up until the 1980s.

Strahan (2003) argues that several events contributed to a shift in the political balance between advocates and opponents of the restrictions. The Office of the Comptroller exploited a loophole in the laws to allow nationally chartered banks to branch freely under certain circumstances (see Strahan, 2003), which created a precedent. The failure of many savings and loan associations in the 1980s also changed the public perception of the laws, since they prohibited a better diversified, more resilient banking sector.

In the 1970s and 1980s, however, the political landscape changed as a result of technological change. As Kroszner and Strahan (1999) explain, technological and financial innovations, such as cash machine tellers and credit scoring reduced the relative advantage of local banking, which tipped the balance to expansion-oriented, large banks in

[18] Any bias from banks endogenously converting to bank holding company structure should reduce the likelihood that I find a significant result and so I am not concerned about this particular possible bias.

the political struggle between opponents and supporters of geographic restrictions. As evidence they show that states with fewer small banks deregulated sooner, as well as states where small banks are financially weaker. Thus, while deregulation itself was a result of an exogenous process (technological advances), the timing of its implementation seems to be endogenous.

This means, that cross-sectional comparisons between states the deregulated and did not deregulate may give results that are difficult to interpret in a causal sense. To illustrate the problem, take banks in a single year. If one were to find that banks in states that already deregulated have more heterogenous balance sheets relative to banks in states that prohibit entry by banks chartered in other states, then it could be that banks chose to become more diverse after deregulation. However, it could also be that bank size and balance sheet heterogeneity are positively correlated and large banks successfully lobbied for deregulation.

Differencing, however, takes care of such concerns. In the regressions I exploit variation over time, similarly to Strahan (2003), who uses a difference-in-difference approach to estimate the effect of deregulation on economic performance. In the example above if banks did not change their balance sheets over time and the cross-sectional correlation between deregulation and balance sheet diversity is a result of banks' lobbying for early deregulation, then the difference-in-difference estimator should correctly yield a zero coefficient on the parameter of interest.

3.3. Hypotheses and econometric approach

In this section I describe the economic channel I aim to identify, then I explain how the lifting of the cross-state banking restrictions in the US can be used as a natural experiment for this purpose.

3.3.1. Last bank standing channel

The last bank standing theory predicts that bank decisions are strategic substitutes because surviving banks can benefit from the failure of their peers. For example healthy banks can reap the gains from increased market power as a result of fewer competing banks on the market; they can take over distressed banks' assets at fire sale prices; or through mergers, potentially backed by regulatory assistance. As an example of the last channel, in the US the Federal Deposit Insurance Corporation (FDIC) signs so called loss-sharing agreements with acquirers of distressed banks. In these agreements the FDIC takes over some of the future losses on the loans in the acquired banks' books. So while a failed bank may have negative market value, its acquisition can be a positive NPV transaction for the acquirer.

Bank decisions being strategic substitutes means that banks have an incentive to avoid investing in the same assets, lending to the same industries or choosing similar funding strategies. The reason for this is simple: the gains from surviving the failure of another bank can only be realized if the acquiring bank itself is not facing financial difficulties: a distressed bank is less likely to be able to fill the gap in credit supply created by the distress of other banks because of funding constraints, while bidding for fire-sale assets is also more difficult for the same reason. Since common exposures on both the asset and liability sides of banks' balance sheets increase the likelihood of experiencing distress at the same time, the last bank standing channel asserts that banks invest in different assets, lend to different sectors and/or choose different funding strategies. For example, a bank that wants to benefit from such a contrarian strategy may choose not to extend commercial loans if other banks have large exposure to that sector. Keeping a larger equity buffer or relying less on short-term wholesale funding is another strategy to avoid joint failure.

3.3.2. Empirical strategy

Empirically identifying strategic interaction is a difficult task, because the expected pattern, say healthy banks acquiring the assets of failing banks, can also be a result of luck, risk aversion or other exogenous factors. In this paper I use the lifting of the cross-state banking restrictions in the U.S. as a source of exogenous variation. The idea behind this is that this policy change arguably changed the incentives of banks to strategically interact if they were located in different states. In particular, take two banks from different states. Before the policy change they operated in separate markets and as such they did not directly compete with one another and could not acquire the assets of the other bank. Consequently, they had no incentive to strategically interact. This changed, however, with the implementation of bilateral agreements between states to allow state-chartered banks to mutually enter the other state's market. Once such an agreement between two states was in effect the scope for banks of these states to strategically interact widened. This suggests that banks located across state borders might have increased the difference between their business models after the policy change in order to avoid joint distress. The policy change did not affect the regulatory environment for banks vis-à-vis other banks located in the same state, since acquisition of other same-state chartered banks' assets and direct competition was already allowed before. This suggests that banks had no incentive to change the composition of their balance sheets relative to other banks of the same state.

The empirical strategy of this paper rests on the hypothesis that banks increased the relative dissimilarity of their business models compared to banks located in other states, while they did not do so relative to their peers in the same state following the lifting of cross-state banking restrictions. To capture this difference I estimate a difference-in-difference model on quarterly merger level observations, where I compare the change of the similarity of bank balance sheets of pairs of banks located in different states, from before to after the policy change, with the change in the similarity of pairs of banks located in the same state. In principle one could use the sample of all pair-wise relations between banks to test the hypothesis that banks' balance sheets became more diverse across states relative to intrastate bank relationships. This is technically challenging, since the number of all pairwise combinations of banks is large. This problem could be alleviated by looking at more aggregated measures of bank balance sheet diversity, for instance at the county instead of bank-pair level. However, there is also a theoretical argument for restricting the sample of all possible cross-state pair-wise bank relations for the purpose of identifying the last bank standing channel. The argument is that not all banks are expected to follow this strategy. In fact, there is a large literature, which argues that bank decisions are strategic complements as a result of which banks follow similar investment and funding strategies. The herding literature argues that strategic complementarity arises because of bailout policies Acharya and Yorulmazer (2007), managerial incentives Rajan (1994), or portfolio diversification Wagner (2010).

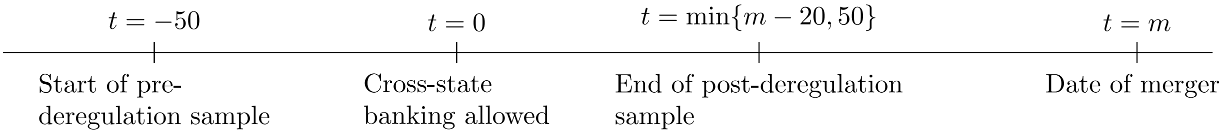
It is likely that in reality at least some banks choose a herding strategy to take advantage of the gains that it provides. For example in Martínez-Miera and Suarez (2012) banks can invest in a systemic asset, which yields the same return for all banks that invested in it, and in idiosyncratic assets with uncorrelated returns. They show that in equilibrium a fraction of banks invest in systemic assets, taking advantage of risk-shifting due to limited liability; while the rest of the banks choose non-systemic investments, capitalizing on high rents received when systemic banks are undercapitalized. The last banking standing strategy and herding may thus coexist. This, however, makes identification more difficult, since we do not observe banks' strategy choice. To overcome this problem I use the outcome of being involved in a distressed merger as a proxy for a bank's decision to aim to become a last bank standing. I operationalize this idea by restricting the sample to pairs of banks that merged while one of them was in distress. Additionally, in some specifications I also include non-distressed mergers. These observations are useful because they help eliminate differences in time trends between intra and inter-state bank-pairs. I explain this in greater detail below.

To summarize, I expect that by comparing pairs of banks that were later involved in a distressed merger I find that the difference between their business models increased after the lifting of cross-state banking restrictions if they were located in different states relative to pairs of banks chartered in the same state. The setting in this paper is somewhat different from a traditional natural experiment setup, in which a group of subjects receive treatment and one looks for a change in behavior after the intervention. In this case the intervention removes a special treatment by allowing cross-state banks to have the same status as intra-state acquirers. Another difference is that after the treatment banks eventually merge, which is endogenous with respect to banks' heterogeneity decision. Therefore, restricting the sample to distressed mergers creates a selection bias. This bias is similar to an omitted variable bias Heckman (1979). Note that sample selection in this case is static, because it depends on bank characteristics at the time of the merger. Thus, merger fixed effects can control for selection bias.

3.4. Data

The sample consists of all bank mergers in the United States since 1976 up to 2013. Information on the mergers of banks and bank holding companies (BHC) is published by the Federal Reserve Bank of Chicago. I exclude bank holding companies for several

Figure 3.1: Timeline



reasons. Firstly, the multi-bank structure of some BHCs creates complications about the calculation of the distance measures, for instance it is not clear if I should use consolidated balance sheet data for BHCs when I compare them with stand-alone banks or treat each subsidiary as a separate observation. Second, the 1982 Garn-St Germain Act allowed BHCs to acquire failing banks across states before the majority of state level deregulation started.

I match the merger database with balance sheet data from Call Reports. Next, I drop all banks from the sample that changed location from one state to another during the sample period. One concern about the econometric setup is that as a bank receives negative shocks to its balance sheet it becomes more likely to become a target in a distressed merger. To tackle this endogeneity problem I exclude 20 quarters of observations prior to the merger, based on the assumption that a bank can recapitalize or readjust its loan portfolio in five years if it intends to. Finally, I exclude observations more than 50 quarters before and after the date of deregulation. I do so to make the panel more balanced, as there are only few observations at either end of the sample period. Figure 3.1 explains the timeline of events: the pre and post-deregulation period each consist of 50 quarters, unless the merger happened sooner than 70 quarters after deregulation, in which case the post-deregulation period ends 20 quarters before the merger date.

Finally, I winsorize all bank level data at the 1st and 99th percentiles to reduce potential biases due to outliers. In the final sample I have 149,788 quarterly balance sheet observations spanning the years from 1976Q2 through 2000Q4 of banks merged during the years of 1976 through 2013.

The main dependent variable is a measure of how different banks' business models are. To construct this variable I first define and calculate a set of balance sheet ratios and financial variables, which then I aggregate into an overall index. This index reflects the distance between the financial ratios of two banks. For banks i and j in quarter t it is then defined as the n-dimensional Euclidean distance:

$$y_{ijt} = \sqrt{\sum_{f} (x_{ift} - x_{jft})^2}, \tag{3.1}$$

where f indexes financial variables denoted by x. This approach is similar to Cai et al. (2011) who use this measure to measure the similarity of banks' loan portfolios. In their case x is the share of loans a bank extended to firms in a given sector relative to total loans.

I follow two general criteria to select the dimensions (x) along which I compare banks: 1) they should be commonly used variables to describe bank balance sheet decisions both on the asset and liability sides[19], and 2) they should have sufficient data coverage throughout the sample period. The second criterion is important, because some of the variables were not reported in early years in the Call Reports. After reviewing data availability I arrived at the following bank characteristics:

The shares of lending to the real estate, agriculture, commercial, household, credit card, and all other sectors relative to total loans are the first set of financial ratios. Next, total loans to total assets measures how much a bank is involved in traditional loan extension and how much it relies on fee generating business. Fixed assets to total assets is a proxy for the size of a bank's branch network, which is related to how it acquires deposits and retail customers. The last asset side component is credit growth, which is excess credit growth of a bank relative to the median county level credit growth, capturing a bank's aggressiveness in loan expansion.

On the liability side I include leverage, defined as total liabilities to total assets, to reflect a bank's capitalization level, which is the primary buffer for banks to absorb losses. Deposits to total liabilities is a measure of how much stable funds a bank has and finally deposit growth is excess growth of deposits relative to the median bank in

[19] Most of the theoretical literature took the approach of modeling the endogenous correlation of shocks to banks' balance sheets as a portfolio choice decision (Acharya and Yorulmazer, 2007; Acharya, 2009; Farhi and Tirole, 2012). For example, in Acharya and Yorulmazer (2007) banks choose the industry in which they invest, which determines the correlation of their portfolio returns. However, endogenously correlated bank funding shocks are also possible and plausible. The choice between more whole sale, short term funding and stable deposit funding can be one such example. An early version of Chapter 2 featured a theoretical model in which banks chose the correlation between their funding costs. In addition, while the correlation of shocks is assumed to be determined on the asset side in the above cited papers, strategic complementarities may arise on the liability side, as in Farhi and Tirole (2012). In their paper banks herd on excessively relying on short debt financing in expectation of a bailout when a systemic shock arrives.

the county of residence.

I then aggregate these components into an overall index of dissimilarity of two banks' business models (*Total distance*) and two subindices measuring dissimilarity on the asset (*Asset distance*) and liability sides (*Liability distance*).

Next, data on the time of state-by-state deregulation are obtained from Amel (1993). This contains for each state the year of the first bilateral agreement with another state allowing inter-state banking. The dummy variable *Post* indicates that the state where the target bank is chartered had at least one bilateral agreement allowing cross-state banking in a given quarter. Table 3.A2 in the Appendix lists the years of deregulation for each state.

I also create several dummy variables for bank-pair characteristics. Cross-state is a dummy variable indicating that banks are chartered in different states. Distressed is a dummy variable, which indicates that there was regulatory involvement in the merger.

Among the control variables are bank and county characteristics separately for acquiring and target banks. Bank size (Acquirer) is taken to be the natural logarithm of total assets of the acquirer. Bank size (Target) is similarly calculated for the target bank. I control for differences in size because small banks may choose to follow a herding strategy to exploit too-many-to-fail subsidies, and because large banks may have better diversification opportunities, which would also affect the similarity of their loan portfolios.

Average total/asset/liability distance (Acquirer) and Average total/asset/liability distance (Target) are included to capture county level trends in bank heterogeneity. It is calculated as follows. Suppose bank i acquired bank j. Then for each bank i that reported Call reports (thus including those that never merged) I calculate the average pairwise distance measure y_{klt} between all other banks (i.e. for all $i, j \neq \{k, l\}$) in the county of bank i. This yields a bank specific, county level measure of bank heterogeneity for the acquirer bank. Average distance figures are obtained similarly for target banks.

Next, the number of banks in the county of a target bank's location (No banks (Target)) proxies for competition and thus the potential benefits from a merger, suggesting a negative relationship between the number of banks and the incentives to try to merge with a failing bank. Contrary to this channel, a higher number of banks in the vicinity of target banks may increase the chances of a bailout should a systemic failure occur, which benefits the acquirer if it is correlated with the target bank. The number of banks in the county of the acquiring bank (No banks (Acquirer)) controls for differences in the likelihood of being able to acquire a failing bank as well as the potential benefits from a merger, since a higher number of local banks increases the number of potential bidders. Finally, I include merger, time and in some specifications state-time dummies. The latter control for macroeconomic factors, such as GDP growth and inflation, which may be correlated with both bank heterogeneity and the propensity to merge. Other factors that influence the likelihood of mergers that are constant over time, such as geographic distance, are controlled for by merger fixed effects.

Table 3.1 shows descriptive statistics of the main variables. Figures 3.2-3.4 show the evolution of average bank distance measures for four subsamples depending on wether the banks were involved in a distressed merger and whether they were located in the same state. Figure 3.2 shows that throughout the sample period non-distressed, intra-state mergers involved more similar banks than other types of merger. Prior to deregulation all bank-pairs seem to have been on a similar trajectory in terms of the diversity of their business models. After deregulation, banks that were later involved in distressed mergers, across states, chose different business models as measured by the distance index. This tendency remained throughout the post-deregulation era, except for a brief interim period. The slightly higher balance sheet difference for this short period is a result of two trends. Banks located in different states became more similar over time, which may be the result of better geographic diversification after deregulation and an increase in the diversity of banks that later merged in an intra-state, distressed merger.[20]

Figure 3.3 shows similar tendencies in bank asset heterogeneity to what we have seen in Figure 3.2. The graph of Liability distance in Figure 3.4 reveals small differences between the four groups of merging banks. In particular, the difference between the liabilities of banks involving cross-state mergers is larger than that of banks that merged within a state. This can indicate that there were cross-border barriers to accessing local funding markets and banks could have gained access to more diversified funding through merger.

[20]It is difficult to pin down the exact reasons of short term fluctuations in the balance sheet distance variables, because various state and country level macroeconomic shocks also affect them. I control for these shocks in the regressions.

3.4.1. Parallel paths assumption

The interpretation of the empirical results in this paper rests on the parallel paths assumption. In a typical case this means that the outcome variable of the treatment and control groups follow the same trends before and after the treatment in the absence of treatment. Since the outcome variable of the treated group without treatment is not observable post-treatment, this assumption is not testable. Instead, it is common practice to test the equality of the trends of the treatment and control groups pre-treatment.

While I assume a version of the parallel paths, which I formally spell out in section 3.5, in this paper the pre-treatment equality of trends is not testable. The reason for this is that the policy-change removed a source of heterogeneity, and as a result, the "treatment" and control groups are expected to be heterogenous before, and in the absence of immediate adjustment, after the policy change. Instead, I compare groups of banks near the end of the sample period, by which time I assume all adjustment has taken place. The results are presented in Tables 3.3 and 3.4.

Table 3.3 shows the number of observations, means and standard deviations of balance sheet variables, also used to calculate the balance sheet distance variables, at the end of 1999, for four subsamples: acquiring banks involved in distressed, cross-state mergers; distressed intra-state mergers; non-distressed, cross-state mergers and non-distressed, intra-state mergers. Table 3.4 shows the same statistics for various groups of target banks. The tables show that there is limited variation in the means of the variables across groups. For example, the means of the Share of real estate loans (relative to total loans) are 0.544, 0.588, 0.593 and 0.599 in the four groups of acquiring banks. In about half the cases the F tests on the joint equality of the means are accepted, in the other half they are rejected (not reported). Still, the message of these tables is that the four groups of acquired banks, and the four groups of target banks, which form the basis of identification, are not radically different in 1999.

3.5. Results

In this section I present how bank balance sheet differences changed after deregulation for different groups of banks depending on whether they were located in different states and whether they merged in a distressed merger. The prediction of the last bank standing channel is that the differences of the balance sheets of banks located in different states increased relative to same-state banks, especially in the sample of banks that merged in distress.

3.5.1. Changes in the unconditional means of bank business model distance

Table 3.2 shows the unconditional changes in the three balance sheet distance variables for various subgroups. The mean of Total distance for distressed, cross-state mergers before deregulation is 0.423, which increased by 0.0239 on average in the post-deregulation period. This is consistent with these banks changing their balance sheets to position themselves to be able to benefit from the potential failure of other banks. However, this could also be a result of sample selection: more different banks being more likely to merge in a distressed merger. Thus, this has to be compared against the change in Total distance for banks involved in distressed mergers within the same state, which is 0.0153. Overall, the increase in the unconditional mean in Total distance is thus larger for the focus group than for the control group.

The change of Total distance between banks that were involved in non-distressed mergers is much smaller. Among cross-state banks the change is in fact negative (-0.02), while slightly positive among bank-pairs in the same state (0.007). It is worth noting that the changes among same-state banks, in either distressed or non-distressed mergers, are closer to zero than either group of cross-state pairs of banks. This is encouraging, because bank-to-bank differences within the same state should have been affected the least by the policy for the natural experiment to be valid.

Turning to Asset distance, I find similar patterns to those obtained for Total distance. On the other hand, banks were less different even before deregulation, and the changes are also much less significant, on the liability side. Finally, Liability distance for all four groups of bank-pairs seems to have followed similar trends, as the respective changes from before deregulation to after deregulation are 0.003 for cross-state, distressed mergers;

intra-state, distressed mergers; and intra-state, non-distressed mergers; and 0.005 for cross-state, non-distressed mergers.

While comparing unconditional means is illuminating, it does not provide an exact estimate of the effect of the policy change. In the next section I present the results of the difference-in-difference regressions, which are better suited for this purpose.

3.5.2. Difference-in-difference regressions

In regression (1) of Table 3.5 the dependent variable is the overall distance measure and the sample includes all distressed mergers. The variable of interest is *Post*×*Cross-state* and it obtains a negative, albeit insignificant coefficient of -0.0235. This negative result could be because deregulation affected cross-border bank heterogeneity differently from intra-state heterogeneity. I later explore this possibility in regressions (2)-(4). Still in regression (1), *Post* has a positive, but insignificant coefficient, which is consistent with the hypothesis that banks located within the same state had no incentives to increase or decrease the relative distance of their business models from one another. Next, both target size and acquirer size are negatively related to the heterogeneity between merging banks (as shown by the negative coefficients on *Size (Target)* and *Size (Acquirer)*), but this effect declines with size as captured by the negative coefficients on the quadratic terms. This pattern is consistent with larger banks' better diversification opportunities, which results in more similar business strategies for these banks. There also seems to be a positive peer effect, in that mergers taking place in counties where banks' balance sheets are more diverse themselves involved more heterogeneous banks in the transaction as shown by the positive and significant coefficients on *Average total distance* (for both target and acquiring banks). This is consistent with herding behavior. Lastly, the number of banks in the county of either the target or the acquirer bank is negatively related to bank balance sheet differences. This is expected, as a higher number of competitors in the vicinity of the target should ceteris paribus lower the benefits from bank take-overs and hence the incentives to distort the optimal business mix in expectation of a possible merger.

It is possible that I do not detect a significant change in bank balance sheet differences among cross-state bank-pairs, because there was a general trend among banks of different states to become more similar. Such a tendency could be explained by an increase in competition closer to state borders as well as banks' increased options to diversify geographically (cf. Goetz et al., 2013). I control for differences in trends between inter and intra-state bank-pairs by extending the sample to include non-distressed mergers. Triple differencing then eliminates trends under the assumption that same-state (cross-state) banks involved in distressed mergers would have followed the same trend paths as same-state (cross-state) banks involved in non-distressed mergers, had deregulation not taken place. To see how, assume that the distance between bank i and j's balance sheet at time t can described by the following processes:

$$y_{ijt}^{di} = \alpha_{ij}^{di} + \delta_t^i + \varepsilon_{ijt}^{di} \tag{3.2}$$

$$y_{ijt}^{dx} = \alpha_{ij}^{dx} + \delta_t^t + \varphi D_t + \varepsilon_{ijt}^{dx} \tag{3.3}$$

$$y_{ijt}^{ni} = \alpha_{ij}^{ni} + \delta_t^i + \varepsilon_{ijt}^{ni} \tag{3.4}$$

$$y_{ijt}^{nx} = \alpha_{ij}^{nx} + \delta_t^x + \varepsilon_{ijt}^{nx}, \tag{3.5}$$

where y is the balance sheet distance measure as defined before, superscript d (n) denotes distressed (non-distressed) mergers and superscript i (x) indicates that the banks involved in the merger are located in the same (different) state(s). For simplicity assume that there are only two time periods, $t = 1$ before deregulation and $t = 2$ after deregulation. D_t is a dummy for the post-deregulation time period, φ is the effect of deregulation. ε_{ijt}^{di}, ε_{ijt}^{dx}, ε_{ijt}^{ni} and ε_{ijt}^{nx} are random error terms. The critical assumption is that intra-state (cross-state) bank-pairs follow the same trends irrespective of wether they were involved in distressed or non-distressed mergers. Triple differencing then eliminates all time invariant effects (the αs) and trends (the δs):

$$\left(\Delta y_{ij}^{dx} - \Delta y_{ij}^{di}\right) - \left(\Delta y_{ij}^{nx} - \Delta y_{ij}^{ni}\right) = \varphi + \left(\Delta\varepsilon_{ij}^{dx} - \Delta\varepsilon_{ij}^{di}\right) - \left(\Delta\varepsilon_{ij}^{nx} - \Delta\varepsilon_{ij}^{ni}\right) \tag{3.6}$$

In column (2) of Table 3.5 I report the results of estimating a regression of Total distance on the triple interaction between *Cross-state*, *Post* and *Distressed*. In addition to the control variables of regression (1) I also add the interaction between *Post* and *Distressed* and two sets of state-time dummies for target and acquiring banks. These dummies capture all time varying macroeconomic factors that might be related to the balance sheets of banks and thus the distance measure. For example, an economic downturn can push some banks into distress and simultaneously increase the correlation between banks. The sample now includes all mergers in the US between 1976 and 2013. The triple interaction obtains a positive coefficient of 0.0477, which is significant at ten percent. *Post* $\times$ *Cross-state* obtains a negative and significant coefficient (-0.0623). These results suggest that overall cross-state bank heterogeneity decreased after deregulation relative to intra-state bank heterogeneity. This effect is significantly smaller among banks that were later involved in distressed mergers, which is consistent with the last bank standing channel. Furthermore, the coefficient of *Post*$\times$*Distressed* is insignificant and negative. Thus, banks involved in intra-state distressed mergers did not become significantly more different after the policy change, which is expected given that their incentives were not changed. As in regression (1) I find that overall bank heterogeneity increased over time in the sample of merging banks as witnessed by the positive coefficient of *Post*. The other variables obtain very similar coefficients compared with those in regression (1): the signs, magnitudes and significance levels are all very similar. This suggests that bank business model differences of banks later involved in distressed mergers do not correlate significantly differently with observables then those of banks later involved in non-distressed mergers. This justifies the pooling of distressed and non-distressed mergers in regressions (2)-(4).

Let us consider now the magnitudes of the estimated effects. The interpretation of the coefficients is not easy because of the triple-differencing. For simplicity let us just take the coefficient of the triple interaction. The estimated effect of deregulation on Total distance that cannot be explained by trends in balance sheet difference of banks that merged in distress and were located across states, and of banks that merged in ordinary mergers, is then 0.0477, as seen in regression (2) of Table 3.5. Thus, the increase in bank heterogeneity attributable to other factors, including the last bank channel, is about 27% of one standard deviation of Total distance, which equals 0.174 (as seen in Table 3.1).

I next look at Asset distance and Liability distance. This breakdown sheds further light on the behavior of banks involved in distressed mergers. Regression (3) of Table 3.5 is analogous to regression (2) with the exception that the dependent variable is the Asset distance index. The main variable of interest, *Post*$\times$*Cross-state*$\times$*Distressed*, obtains a positive and significant (at ten percent) coefficient of 0.0550. As before, I find that banks involved in intra-state non-distressed mergers became more different after deregulation as shown by the positive coefficient on *Post*. Cross-state merging banks on the other hand became more similar, as the sum of the coefficients on *Post*$\times$*Cross-state* and *Post* is negative ($-0.214 = -0.0575 + 0.0361$). Lastly, In regression (4) the dependent variable is the liability distance measure. In this case I do not find a positive effect, the relevant coefficient estimate is negative (-0.00449) and insignificant. Meanwhile, the tendencies among cross-state non-distressed mergers and intrastate mergers are very similar to the case when asset, rather than liability distance, is considered. This is shown by the significant coefficients of *Post*$\times$*Cross-state* and *Post*, -0.0192 and 0.0271, respectively.

3.5.3. Robustness checks

In this section I carry out a number of additional tests to confirm the robustness of the results. First, I shorten the period during which banks' balance sheets are analyzed to include 30 quarters before and after deregulation, while still excluding at least 20 quarters before the date of a merger. Second, I exclude mergers that occurred during 2007 or later. The latter serves two purposes: on the one hand the industry might have changed during the time period between the elimination of cross-state banking restrictions and the second half of the 2000s. This period is at least a decade long if one counts from the passing the Riegle-Neal Act, which removed barriers to cross-state banking federally, and nearly three decades long in some states that deregulated early. It is not likely that banks that were potential targets remain so for such a long period. Second, the cut-off year serves to exclude the effect of the crisis.

The results are presented in Table 3.6. In regressions (1)-(3) I reestimate regressions (2)-(4) of Table 3.5, but the regressions include at most 30 quarters of observations before and after the end of the year in which the state of the target bank deregulated. In regression (1) Total distance is the dependent variable and the variable of interest is the triple interaction of Distressed, Post and cross-state. This obtains a positive coefficient of 0.0441, which is significant at 10 percent. In regression (2) the dependent variable is Asset distance and the coefficient of the triple interaction term is also positive (at 0.0480) and significant. Lastly, in the Liability distance regression in column 3 the triple interaction obtains an insignificant coefficient. Thus, the result, that banks involved in cross-state, distressed mergers had more different balance sheets after deregulation than banks that merged inside a state or not in distress, seems robust to the length of the observation period around deregulation.[21]

In the right hand side panel the observation period is ±50 quarters around the end of the year of deregulation, as in Table 3.5, but the sample excludes mergers after 2006. In regression (4) total distance is regressed, among other variables, on the triple interaction of Distressed, Post and cross-state, which has a coefficient of 0.122, significant at the 5 percent level. Replacing the dependent variable by asset distance yields a similarly significant coefficient on the triple interaction of 0.108. Finally, in the liability distance regression the triple interaction has a coefficient of 0.0643, also significant at five percent. Compared to the analogous regressions in Table 3.5, when the full sample is considered, the estimated effect of the deregulation seems larger, as evidenced by the larger coefficient estimates of the triple interactions. In addition, while the triple interaction has a negative, insignificant coefficient in the liability distance regression (regression (4) in Table 3.5), this coefficient is positive and significant when the mergers close to the end of the sample period are ommitted (see in regression (3) in Table 3.6). This pattern is expected since banks, that merged close to the end of the sample period, may not have anticipated a potential merger so far in the future at the time of deregulation, or alternatively, they may not have been competitors then. This suggests that they might have lacked an interest to play a strategic game to become last bank standing, in turn explaining the stronger results in the right panel of Table 3.6, when only mergers closer to deregulation are considered.

3.5.4. The effect of early deregulation

In this section I investigate whether banks in states that deregulated early changed their balance sheets after deregulation has occurred more relative to banks in states that were slow to deregulate. This is expected if banks, in states that entered into agreements with other states to allow cross-state banking relatively late, anticipated deregulation, and changed their lending and funding activities before the new laws were in effect. Banks in states that were early adopters, on the other hand, might not have expected deregulation, suggesting that any adjustment took place after deregulation. To answer this question I split the sample into target banks that are headquartered in states that

[21] In unreported regressions I find qualitatively similar results when the observation period is ±20 or ±40 quarters around the year of deregulation. In particular, in both the total and asset distance regressions the triple interaction of Distressed, Post and cross-state obtain positive and significant coefficients.

deregulated before the end of 1986 and banks located in all other states. 1986 yields an approximately equal number of states that are early adopters (28 states) and late adopters (23 states).

Table 3.7 shows the results of regressions analogous to regressions (2)-(4) of Table 3.5, for the two subsamples. In regressions (1)-(3) the sample is restricted to mergers where the state of the target bank deregulated before 1986. In the total distance and asset distance regressions, in columns (1) and (2), the triple interactions obtain positive coefficients at 0.0561 and 0.0623, respectively, both significant at ten percent. The coefficient in the liability distance regression, on the other, yields a negative and insignificant coefficient on the focus variable.

Turning to the sample of mergers, where the target banks' states deregulated after 1986, in regressions (4)-(6) I find no significant coefficients on the triple interactions regardless of the balance sheet distance variable. To be precise, in columns (4)-(6) we can see that when total distance or asset distance is regressed on the interaction of Distressed, Post and cross-state, the estimated coefficients are positive, but about an order smaller than in regressions (1)-(2), in which the sample is restricted to states that deregulated early. When the dependent variable is liability distance the magnitude of the relevant coefficient is about the same in regression (6) as in regression (3), and is also insignificant. These results suggest that banks did not anticipate the relaxation of cross-state banking restrictions in the early phase of the deregulation, and hence, did not adjust a priori. Conversely, banks might have anticipated that further elimination of the restrictions was coming ahead after the initial wave of deregulation, and adjusted already before the new agreements were implemented.

3.6. Probability of merger

The aim of this section is to test if the distance measures predict distressed mergers. I test this by running probit regressions. Before describing the specifics of the regressions, I explain the construction of the sample used in this section.

3.6.1. Sample and methodology

Since the total number of possible bank relations is large ($N(N-1)/2$), I create a sample from random draws that has a manageable size. First I take all target banks from the merger sample used in the previous sections. Then I randomly select (with replacement) 40 banks for each failing and non-failing target bank, where failing targets are those involved in distressed mergers and non-failing target banks are all other targets. Since most mergers happen locally or within small distances, I limit the sample of "acquirer candidates" to banks headquartered at most 250km away from the target bank. Without this restriction I would have a diminishingly small proportion of actual mergers in the sample.

I then create a dummy variable, which takes the value of one if the randomly selected bank-pair actually merged and zero otherwise. Similarly, I create a dummy variable, which I call *Distressed*, to indicate that the target bank was a failing bank. Finally, I calculate the distance variables for all bank pairs and calculate the average distance during the post-deregulation period for each bank-pair. Using the thus obtained cross-sectional sample I estimate the likelihood of mergers conditional on the distance variables and their interactions with *Distressed*.

3.6.2. Results

Columns (1) to (3) of Table 3.8 present the results of probit regressions using the three distance measures: total distance, asset distance and liability distance, in this order. I find that for both total distance and asset distance more similar banks are more likely to merge if the target bank was not failing as suggested by the negative and significant coefficient on the business model distance variable. For failing target banks, however, more different banks seem more likely to be successful bidders. In regressions (1) and (2) the coefficients of the interaction between either Total or Asset distance and the distressed dummy are positive and significant at least at 10 percent. The total impact of business model distance is also positive, although the t-tests cannot reject the null of it being significantly different from zero (the tests yield a p value of 0.22 in both cases). Nonetheless, consistent with my expectations, the results suggest that more different banks are more likely to be able to acquire failing banks. Consistently with the results in the previous section, where I did not find a significant impact of deregulation on

Liability distance, I do not find a significant relationship between this distance measure and the likelihood of a distressed merger.

The results in this section can be used to provide an estimate of the impact of deregulation on the likelihood that a bank successfully acquired a distressed bank in another state. To calculate this figure I take the average of Total distance in the group of cross-state, distressed mergers before deregulation, which equals 0.423 as seen in Table 3.2. Using the estimates of regression (1) in Table 3.8, the estimated conditional likelihood that a bank acquired a distressed bank is $\Phi(-2.269 - 0.461 + (-0.432 + 0.711) * 0.423) = 0.0045$, where Φ denotes the cumulative density function of the standard normal distribution. Adding the effect of deregulation, which is the coefficient on the triple interaction in regression (2) in Table 3.5, yields an increased probability of $\Phi(-2.269 - 0.461 + (-0.432 + 0.711) * (0.423 + 0.0477)) = 0.0047$. This means that the adjustment in banks' balance sheets after deregulation, possibly as a result of the last bank standing channel, increased the probability that they can acquire a failing bank by about 2 basis points, or 4% = (0.0047-0.0045)/0.0045. This may seem a small change at first glance, but it can be economically significant. The reason for this is that this estimate is for any year, when on average few banks go bankrupt. In a crisis bank failures are much more likely, so the increase in the conditional probability of acquiring a failing bank in a systemic crisis is probably much larger.

3.7. Conclusions

In this paper I introduced a new measure of bank business model difference based on balance sheet data. This measure predicts distressed bank mergers in the sense that the more different two banks are the higher the conditional likelihood that they merge given that one of the banks is in distress. Furthermore, using this measure I showed that banks located across state borders became more different after the lifting of cross-state banking restrictions in the US, if they were later involved in distressed mergers, relative to banks involved in distressed mergers within the same state. This suggests that there were gains for certain banks from becoming more different from their cross-state peers once they were allowed to acquire banks in other states. Furthermore, the adjustment took place on the asset side of banks' balance sheets.

The results suggest that there is scope for policies that aim at containing ex ante systemic risk by reducing the incentives for banks to engage in excessive systemic risk taking. One way of achieving this is through competition policy: allowing banks to acquire failing banks at attractive prices could improve financial stability. One can push this even further by subsidizing the acquisition of failed banks, for which there are various tools including tax credits, access to cheap funding, or even direct subsidies.

3.8. Appendix

Table 3.A1: Variable definitions

Variable	Description	Source
Asset distance	$\sqrt{\sum_f (x_{ift} - x_{jft})^2}$, where x_{ift} (x_{jft}) is the fth business model indicator of the target (acquiring) bank at time t. The set of business model indicators includes real estate loans/total loans, agriculture loans/total loans, commercial loans/total loans, household loans/total loans, credit card loans/total loans, other loans/total loans, total loans/total assets, fixed assets/total assets, credit growth. Credit growth is excess growth of credit relative to the median bank in the county of residence.	FFIEC Call reports
Liability distance	$\sqrt{\sum_f (x_{ift} - x_{jft})^2}$, where x_{ift} (x_{jft}) is the fth business model indicator of the target (acquiring) bank at time t. The set of business model indicators includes total liabilities/total assets, deposits/total liabilities, deposit growth. Deposit growth is excess growth of deposits relative to the median bank in the county of residence.	FFIEC Call reports
Total distance	$\sqrt{(\text{Asset distance})^2 + (\text{Liability distance})^2}$	FFIEC Call reports
Average total distance (Target)	Unweighted average of total distance between all banks in the county of the target bank's residency excluding the target bank itself.	FFIEC Call reports
Average total distance (Acquirer)	Unweighted average of total distance between all banks in the county of the acquiring bank's residency excluding the acquiring bank itself.	FFIEC Call reports
Average asset distance (Target)	Unweighted average of asset distance between all banks in the county of the target bank's residency excluding the target bank itself.	FFIEC Call reports
Average asset distance (Acquirer)	Unweighted average of asset distance between all banks in the county of the acquiring bank's residency excluding the acquiring bank itself.	FFIEC Call reports
Average liability distance (Target)	Unweighted average of liability distance between all banks in the county of the target bank's residency excluding the target bank itself.	FFIEC Call reports

Average liability distance (Acquirer)	Unweighted average of liability distance between all banks in the county of the acquiring bank's residency excluding the acquiring bank itself.	FFIEC Call reports
Distressed	Dummy indicating that there was regulatory involvement in the merger.	Federal Reserve Bank of Chicago - Bank merger database
Merged	Dummy variable indicating that a pair of banks merged.	Federal Reserve Bank of Chicago - Bank merger database
Post	Dummy variable indicating that the state where the target bank is chartered had at least one bilateral agreement allowing cross-state banking in a given quarter.	Amel (1993)
Cross-state	Dummy variable indicating that banks are chartered in different states.	FFIEC Call reports
Bank size (Target)	Natural logarithm of total assets of the target bank.	FFIEC Call reports
Bank size (Acquirer)	Natural logarithm of total assets of the acquiring bank.	FFIEC Call reports
Bank size^2 (Target)	Square of the natural logarithm of total assets of the target bank.	FFIEC Call reports
Bank size^2 (Acquirer)	Square of the natural logarithm of total assets of the acquiring bank.	FFIEC Call reports
No banks (Target)	Number of banks in the county of the target bank's residency.	FFIEC Call reports
No banks (Acquirer)	Number of banks in the county of the acquiring bank's residency.	FFIEC Call reports

Table 3.A2: Year of deregulation by state

The table shows the year when a state first entered an arrangement with another state to allow interstate banking in the other state's jurisdiction.

State	Year	State	Year
Alabama	1987	Montana	1993
Alaska	1982	Nebraska	1990
Arizona	1986	Nevada	1985
Arkansas	1989	New Hampshire	1987
California	1987	New Jersey	1986
Colorado	1988	New Mexico	1989
Connecticut	1983	New York	1982
Delaware	1988	North Carolina	1985
District of Columbia	1985	North Dakota	1991
Florida	1985	Ohio	1985
Georgia	1985	Oklahoma	1987
Hawaii	1997	Oregon	1986
Idaho	1985	Pennsylvania	1986
Illinois	1986	Rhode Island	1984
Indiana	1986	South Carolina	1986
Iowa	1991	South Dakota	1988
Kansas	1992	Tennessee	1985
Kentucky	1984	Texas	1987
Louisiana	1987	Utah	1984
Maine	1978	Vermont	1988
Maryland	1985	Virginia	1985
Massachusetts	1983	Washington	1987
Michigan	1986	West Virginia	1988
Minnesota	1986	Wisconsin	1987
Mississippi	1988	Wyoming	1987
Missouri	1986		

Table 3.A3: Call report items used to calculate financial ratios

Variable	Call report cell id
Total loans	rcfd2122 + rcfd2165 prior to July 1, 1984 and rcfd2122 afterwards
Total assets	rcfd2170
Total liabilities	rcfd2950
Total deposits	rcfd2200
Real estate loans	rcfd1410
Loans to agriculture	rcfd1590
Commerical loans	rcfd1600
Household loans	rcfd1975
Credit card loans	rcfd2008
Other loans	rcfd2080
Fixed assets	rcfd2145

3.9. Figures

Figure 3.2: Total distance over time

The graph plots the average of Total distance among groups of merging banks. Total distance is the Euclidean distance between all financial ratios, as listed in Table 3.A1 in the Appendix, of a pair of banks.

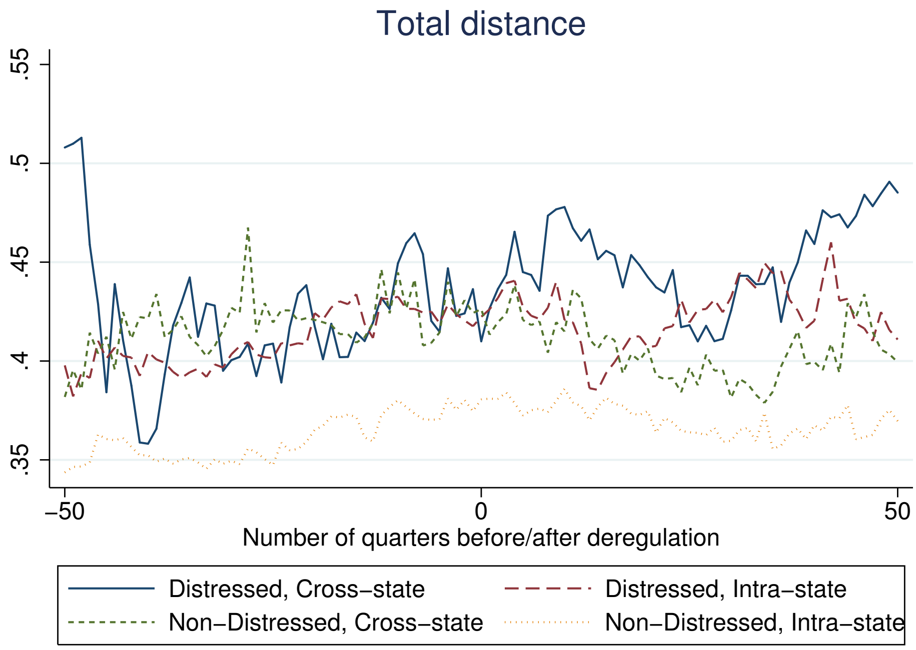


Figure 3.3: Asset distance over time

The graph plots the average of Asset distance among groups of merging banks. Asset distance is the Euclidean distance between all financial ratios, as listed in Table 3.A1 in the Appendix, of a pair of banks.

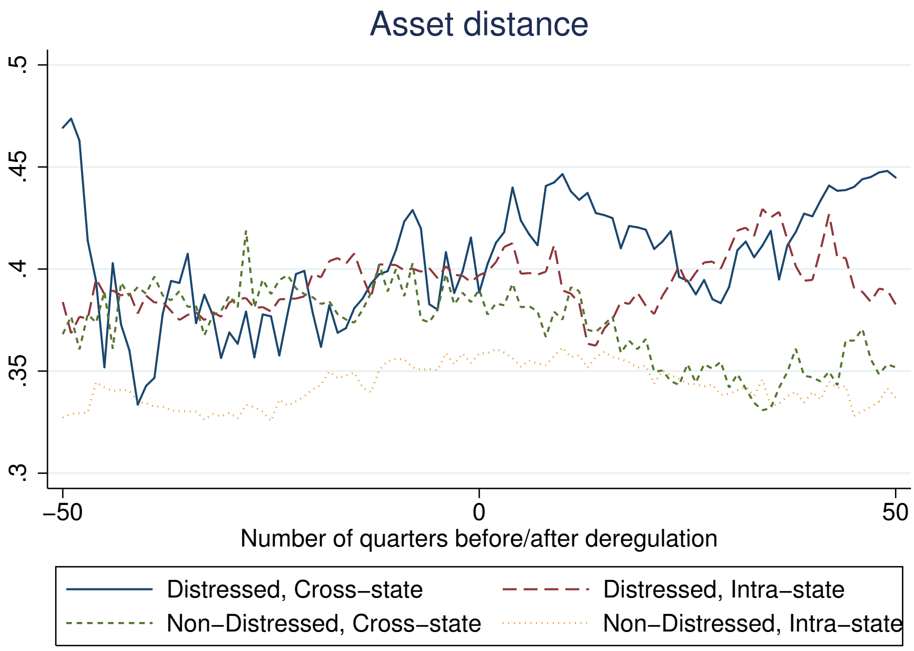
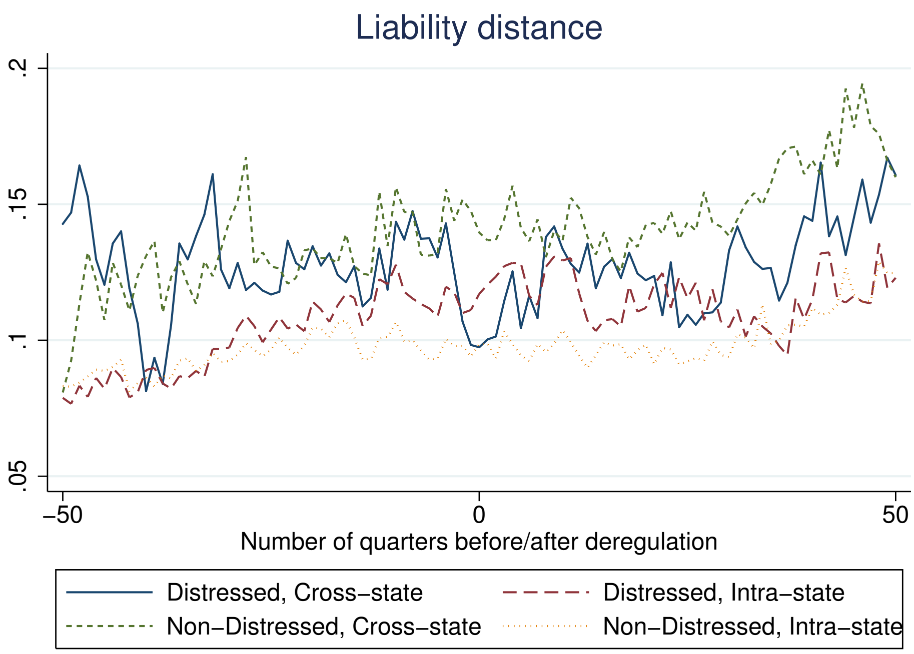


Figure 3.4: Liability distance over time

The graph plots the average of Liability distance among groups of merging banks. Liability distance is the Euclidean distance between all financial ratios, as listed in Table 3.A1 in the Appendix, of a pair of banks.



3.10. Tables

Table 3.1: Descriptive statistics of the main variables

	# of obs	Mean	SD	Min	Max
Total distance	149647	0.378	0.174	0.0241	1.540
Asset distance	149647	0.356	0.168	0.0101	1.447
Liability distance	149647	0.0984	0.0907	0.000442	0.860
Average total distance (Acquirer)	149647	0.379	0.110	0.0443	1.277
Average total distance (Target)	149647	0.376	0.106	0.0443	1.373
Average asset distance (Acquirer)	149647	0.357	0.101	0.0286	1.237
Average asset distance (Target)	149647	0.356	0.0981	0.0335	1.237
Average liability distance (Acquirer)	149647	0.104	0.0668	0.00178	0.680
Average liability distance (Target)	149647	0.0988	0.0642	0.00166	0.856
Size (Acquirer)	149647	11.58	1.717	7.244	19.18
$Size^2$ (Acquirer)	149647	137.2	41.97	52.48	367.8
Size (Target)	149647	10.30	1.217	6.400	17.69
$Size^2$ (Target)	149647	107.6	26.36	40.96	312.8
No banks (Target)	149647	25.98	57.69	2	378
No banks (Acquirer)	149647	25.78	56.90	2	378

Table 3.2: Bank distance before and after deregulation

The table shows descriptives statistics of Total, Asset and Liability distance for different subsamples. Total distance is the Euclidean distance between all financial ratios, as listed in Table 3.A1 in the Appendix, of a pair of banks. Asset distance and Liability distance are the Euclidean distances between asset-side and liability-side financial ratios, respectively, as listed in Table 3.A1 in the Appendix, of a pair of banks. The subsamples are distressed, cross-state mergers; distressed, intra-state mergers; non-distressed, cross-state mergers; non-distressed, intra-state mergers; separately for the pre-deregulation and post-deregulation periods. The penultimate column shows the difference between the means of the pre- and post-deregulation subsamples. The last column shows the t statistics of tests for the equality of the pre- and post-deregulation distances. *, ** and *** indicate significance at the 10, 5 and 1 percent level.

	Pre-deregulation			Post-deregulation				
	# of obs	Mean	SD	# of obs	Mean	SD	Difference of means	t-stat
Total distance								
Cross-state, distressed	1518	0.423	0.182	2621	0.447	0.195	0.0239***	(3.90)
Intra-state, distressed	15476	0.402	0.170	4744	0.417	0.209	0.0153***	(5.12)
Cross-state, non-distressed	6867	0.422	0.175	8594	0.402	0.203	-0.0200***	(-6.47)
Intra-state, non-distressed	71147	0.364	0.159	38821	0.371	0.181	0.00724***	(6.85)
Asset distance								
Cross-state, distressed	1518	0.390	0.172	2621	0.417	0.192	0.0272***	(4.57)
Intra-state, distressed	15476	0.382	0.165	4744	0.397	0.204	0.0150***	(5.16)
Cross-state, non-distressed	6867	0.387	0.168	8594	0.363	0.193	-0.0244***	(-8.28)
Intra-state, non-distressed	71147	0.345	0.155	38821	0.351	0.176	0.00597***	(5.83)
Liability distance								
Cross-state, distressed	1518	0.125	0.121	2621	0.128	0.103	0.00331	(0.93)
Intra-state, distressed	15476	0.0965	0.0884	4744	0.0994	0.0913	0.00298*	(2.02)
Cross-state, non-distressed	6867	0.133	0.112	8594	0.138	0.123	0.00480*	(2.51)
Intra-state, non-distressed	71147	0.0916	0.0822	38821	0.0944	0.0879	0.00285***	(5.36)

Table 3.3: Acquiring banks' balance sheet characteristics at year-end 1999

The table shows the balance sheet characteristics at year-end 1999, which are used to calculate the Total, Asset and Liability distance measures for the sample of banks that acquired other banks during the period of 1976-2013. In the first panel the acquired bank was headquartered in a state different from the acquiring bank's residency and the merger involved regulatory intervention. In the second panel the merger also involved regulatory intervention, but the merger happened within a state. In the third panel the merger did not involve regulatory intervention and the target bank headquartered in a state different from the acquiring bank's residency. The fourth panel involves mergers without regulatory intervention, which happened within a state.

	Cross-state, distressed			Intra-state, Distressed			Cross-state, non-distressed			Intra-state, non-distressed		
	Obs	Mean	SD	Obs	Mean	SD	Obs	Mean	SD	Obs	Mean	SD
Share of real estate loans	77	0.544	0.176	117	0.588	0.165	218	0.593	0.178	785	0.599	0.193
Share of loans to agriculture	77	0.0306	0.0576	117	0.0514	0.0899	218	0.0250	0.0680	785	0.0709	0.122
Share of commercial loans	77	0.212	0.130	117	0.228	0.135	218	0.195	0.116	785	0.193	0.138
Share of household loans	77	0.151	0.124	117	0.110	0.0832	218	0.145	0.126	785	0.116	0.0865
Share of credit card loans	77	0.0196	0.0283	117	0.00742	0.0154	218	0.0193	0.0320	785	0.00544	0.00877
Share of other loans	77	0.0119	0.0226	117	0.00859	0.0184	218	0.0103	0.0177	785	0.00583	0.0119
Total loans/Total assets	77	0.684	0.105	117	0.649	0.115	218	0.677	0.127	785	0.638	0.130
Fixed assets/Total assets	77	0.0201	0.0105	117	0.0189	0.00921	218	0.0188	0.0115	785	0.0180	0.0112
Credit growth	77	0.0447	0.115	117	0.0193	0.0734	218	0.0127	0.0780	785	0.0207	0.0860
Deposits/Total liabilties	77	0.873	0.0886	117	0.912	0.0965	218	0.848	0.121	785	0.910	0.0880
Total liabilities/Total assets	77	0.908	0.0188	117	0.913	0.0228	218	0.907	0.0297	785	0.907	0.0334
Deposit growth	77	0.0518	0.116	117	0.0169	0.0794	218	0.0138	0.0736	785	0.0208	0.0833

Table 3.4: Target banks' balance sheet characteristics at year-end 1999

The table shows the balance sheet characteristics at year-end 1999, which are used to calculate the Total, Asset and Liability distance measures for the sample of banks that acquired other banks during the period of 1976-2013. In the first panel the acquired bank was headquartered in a state different from the acquiring bank's residency and the merger involved regulatory intervention. In the second panel the merger also involved regulatory intervention, but the merger happened within a state. In the third panel the merger did not involve regulatory intervention and the target bank headquartered in a state different from the acquiring bank's residency. The fourth panel involves mergers without regulatory intervention, which happened within a state.

	Cross-state, distressed			Intra-state, Distressed			Cross-state, non-distressed			Intra-state, non-distressed		
	Obs	Mean	SD	Obs	Mean	SD	Obs	Mean	SD	Obs	Mean	SD
Share of real estate loans	77	0.634	0.245	117	0.639	0.213	218	0.597	0.213	785	0.594	0.215
Share of loans to agriculture	77	0.0230	0.0751	117	0.0564	0.110	218	0.0349	0.0891	785	0.0856	0.157
Share of commercial loans	77	0.219	0.183	117	0.176	0.128	218	0.223	0.155	785	0.182	0.136
Share of household loans	77	0.0953	0.117	117	0.113	0.121	218	0.112	0.124	785	0.123	0.116
Share of credit card loans	77	0.00550	0.0198	117	0.00571	0.0170	218	0.00860	0.0230	785	0.00374	0.00944
Share of other loans	77	0.00644	0.0140	117	0.00611	0.0154	218	0.00663	0.0169	785	0.00539	0.0153
Total loans/Total assets	77	0.668	0.137	117	0.647	0.132	218	0.635	0.144	785	0.597	0.149
Fixed assets/Total assets	77	0.0242	0.0180	117	0.0235	0.0172	218	0.0199	0.0163	785	0.0196	0.0151
Credit growth	77	0.0424	0.144	117	0.0374	0.127	218	0.0242	0.115	785	0.0171	0.0997
Deposits/Total liabilties	77	0.935	0.0753	117	0.932	0.0907	218	0.912	0.111	785	0.944	0.0749
Total liabilities/Total assets	77	0.886	0.0720	117	0.898	0.0516	218	0.896	0.0509	785	0.896	0.0444
Deposit growth	77	0.0470	0.132	117	0.0458	0.129	218	0.0262	0.107	785	0.0121	0.0890

Table 3.5: Regressions on bank business model heterogeneity

The dependent variable in regressions (1) and (2) is Total distance, which is the Euclidean distance between all financial ratios, as listed in Table 3.A1 in the Appendix, of a pair of banks. The dependent variables in regressions (3) and (4) are Asset distance and Liability distance, respectively, which are the Euclidean distances between asset-side and liability-side financial ratios, as listed in Table 3.A1 in the Appendix, of a pair of banks. Post is a dummy variable indicating that the state where the target bank is chartered had at least one bilateral agreement allowing cross-state banking in a given quarter. Cross-state is a dummy variable indicating that banks are chartered in different states. Distressed is a dummy, which indicates that there was regulatory involvement in the merger. Bank size is the natural logarithm of total assets. Average total, asset and liability distance are the average of the pairwise total, asset and liability distances, respectively, in the county of a bank's headquarter. No banks is the number of banks in the county of a bank's residency. (Target) and (Acquirer) indicate that a variable is a target or an acquirer bank characteristic. Standard errors are clustered at the merger level. t statistics are shown in parentheses. *, ** and *** indicate significance at the 10, 5 and 1 percent level.

	Distressed mergers	All mergers		
	Total distance	Total distance	Asset distance	Liability distance
	(1)	(2)	(3)	(4)
Post × Cross-state	-0.0235	-0.0623***	-0.0575***	-0.0192***
	(-0.90)	(-5.38)	(-4.82)	(-4.02)
Post × Cross-state × Distressed		0.0477*	0.0550*	-0.00449
		(1.72)	(1.91)	(-0.45)
Post × Distressed		-0.000871	-0.00180	0.00313
		(-0.06)	(-0.13)	(0.81)
Post	0.0173	0.0426***	0.0361***	0.0271***
	(1.02)	(6.76)	(5.69)	(9.68)
Size (Acquirer)	-0.147***	-0.102***	-0.0883***	-0.0423***
	(-3.08)	(-4.78)	(-4.07)	(-4.14)
Size^2 (Acquirer)	0.00537***	0.00443***	0.00371***	0.00213***
	(2.90)	(5.08)	(4.15)	(5.16)
Size (Target)	-0.256***	-0.208***	-0.164***	-0.153***
	(-4.04)	(-7.90)	(-6.22)	(-11.52)
Size^2 (Target)	0.00965***	0.00676***	0.00523***	0.00535***
	(3.34)	(5.49)	(4.22)	(8.66)
Average total distance (Acquirer)	0.295***	0.263***		
	(7.74)	(17.67)		
Average total distance (Target)	0.235***	0.241***		
	(5.97)	(16.41)		
Average asset distance (Acquirer)			0.250***	
			(14.77)	
Average asset distance (Target)			0.239***	
			(14.68)	
Average liability distance (Acquirer)				0.311***
				(26.59)
Average liability distance (Target)				0.248***
				(23.33)
No banks (Target)	-0.000254	-0.0000457	-0.0000490	-0.0000206
	(-1.02)	(-0.38)	(-0.38)	(-0.44)
No banks (Acquirer)	-0.000368**	-0.000206*	-0.000205*	-0.0000693
	(-2.29)	(-1.79)	(-1.71)	(-1.35)
Observations	24359	149788	149788	149788
Adjusted R^2	0.105	0.085	0.072	0.104
Merger effects	Yes	Yes	Yes	Yes
Time effects	Yes	Yes	Yes	Yes
State of acquiror × time effects	No	Yes	Yes	Yes
State of target × time effects	No	Yes	Yes	Yes

Table 3.6: Robustness: shorter sample period and mergers before 2007 only

The dependent variable in regressions (1) and (4) is Total distance, which is the Euclidean distance between all financial ratios, as listed in Table 3.A1 in the Appendix, of a pair of banks. The dependent variables in regressions (2) and (5) is Asset distance, which is the Euclidean distance between asset-side financial ratios, as listed in Table 3.A1 in the Appendix, of a pair of banks. The dependent variables in regressions (3) and (6) is Liability distance, which is the Euclidean distance between liability-side financial ratios, as listed in Table 3.A1 in the Appendix, of a pair of banks. Post is a dummy variable indicating that the state where the target bank is chartered had at least one bilateral agreement allowing cross-state banking in a given quarter. Cross-state is a dummy variable indicating that banks are chartered in different states. Distressed is a dummy, which indicates that there was regulatory involvement in the merger. Bank size is the natural logarithm of total assets. Average total, asset and liability distance are the average of the pairwise total, asset and liability distances, respectively, in the county of a bank's headquarter. No banks is the number of banks in the county of a bank's residency. (Target) and (Acquirer) indicate that a variable is a target or an acquirer bank characteristic. The regressions in columns (2)-(4) include 30 quarterly observations before and after the first year in which the state where the target bank is chartered had at least one bilateral agreement allowing cross-state banking. Regressions in columns (5)-(7) include mergers that occured before 2007 only. Standard errors are clustered at the merger level. t statistics are shown in parentheses. *, ** and *** indicate significance at the 10, 5 and 1 percent level.

	±30 quarters after deregulation			Mergers before 2007		
	Total distance	Asset distance	Liability distance	Total distance	Asset distance	Liability distance
	(1)	(2)	(3)	(4)	(5)	(6)
Post × Cross-state × Distressed	0.0441*	0.0480*	0.00373	0.122***	0.108**	0.0643**
	(1.77)	(1.85)	(0.39)	(2.66)	(2.45)	(2.56)
Post × Cross-state	-0.0454***	-0.0413***	-0.0182***	-0.0552***	-0.0511***	-0.0174***
	(-4.02)	(-3.57)	(-3.71)	(-4.04)	(-3.59)	(-2.96)
Post	0.0290***	0.0254***	0.0189***	0.0412***	0.0352***	0.0268***
	(5.02)	(4.39)	(6.89)	(5.96)	(5.08)	(8.05)
Post × Distressed	-0.00580	-0.00652	0.00347	-0.00625	-0.00396	-0.00953
	(-0.43)	(-0.48)	(0.92)	(-0.26)	(-0.17)	(-1.39)
Size (Acquirer)	-0.122***	-0.115***	-0.0420***	-0.101***	-0.0784***	-0.0602***
	(-4.16)	(-3.96)	(-2.69)	(-4.27)	(-3.34)	(-4.88)
$Size^2$ (Acquirer)	0.00517***	0.00472***	0.00210***	0.00463***	0.00354***	0.00289***
	(4.27)	(3.92)	(3.37)	(4.73)	(3.61)	(5.87)
Size (Target)	-0.242***	-0.179***	-0.229***	-0.217***	-0.168***	-0.163***
	(-6.61)	(-5.04)	(-10.62)	(-7.47)	(-5.90)	(-9.84)
$Size^2$ (Target)	0.00794***	0.00565***	0.00862***	0.00684***	0.00514***	0.00564***

	(4.66)	(3.40)	(8.52)	(4.90)	(3.75)	(7.15)
Average total distance (Acquirer)	0.253***			0.239***		
	(15.28)			(13.85)		
Average total distance (Target)	0.225***			0.256***		
	(13.26)			(15.53)		
Average asset distance (Acquirer)		0.235***			0.223***	
		(12.65)			(11.42)	
Average asset distance (Target)		0.222***			0.256***	
		(11.80)			(14.07)	
Average liability distance (Acquirer)			0.297***			0.295***
			(22.87)			(22.71)
Average liability distance (Target)			0.233***			0.246***
			(19.65)			(20.22)
No banks (Target)	-0.000174	-0.000197	0.0000132	-0.0000273	-0.0000175	-0.0000191
	(-1.16)	(-1.27)	(0.22)	(-0.20)	(-0.12)	(-0.42)
No banks (Acquirer)	-0.00000362	0.0000223	-0.0000180	-0.000246*	-0.000239*	-0.0000887*
	(-0.02)	(0.13)	(-0.26)	(-1.76)	(-1.67)	(-1.67)
Constant	-7.10e-12	-8.40e-12	-1.50e-12	-1.38e-11	2.38e-11	-8.96e-12
	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(0.00)	(-0.00)
Observations	98040	98040	98040	113818	113818	113818
Adjusted R^2	0.079	0.064	0.104	0.084	0.069	0.104
Merger effects	Yes	Yes	Yes	Yes	Yes	Yes
State of acquirer × time effects	Yes	Yes	Yes	Yes	Yes	Yes
State of target × time effects	Yes	Yes	Yes	Yes	Yes	Yes

Table 3.7: The change of bank business model heterogeneity in early vs late deregulating states

The dependent variable in regressions (1) and (4) is Total distance, which is the Euclidean distance between all financial ratios, as listed in Table 3.A1 in the Appendix, of a pair of banks. The dependent variables in regressions (2) and (5) is Asset distance, which is the Euclidean distance between asset-side financial ratios, as listed in Table 3.A1 in the Appendix, of a pair of banks. The dependent variables in regressions (3) and (6) is Liability distance, which is the Euclidean distance between liability-side financial ratios, as listed in Table 3.A1 in the Appendix, of a pair of banks. Post is a dummy variable indicating that the state where the target bank is chartered had at least one bilateral agreement allowing cross-state banking in a given quarter. Cross-state is a dummy variable indicating that banks are chartered in different states. Distressed is a dummy, which indicates that there was regulatory involvement in the merger. Bank size is the natural logarithm of total assets. Average total, asset and liability distance are the average of the pairwise total, asset and liability distances, respectively, in the county of a bank's headquarter. No banks is the number of banks in the county of a bank's residency. (Target) and (Acquirer) indicate that a variable is a target or an acquirer bank characteristic. The regressions in columns (2)-(4) include mergers in states that first allowed banks chartered in other states before the end of 1986, while the regressions in columns (5)-(7) include mergers in state that deregulated in or after 1987. Standard errors are clustered at the merger level. t statistics are shown in parentheses. *, ** and *** indicate significance at the 10, 5 and 1 percent level.

	Deregulation before 1986			Deregulation after 1987		
	Total distance	Asset distance	Liability distance	Total distance	Asset distance	Liability distance
	(1)	(2)	(3)	(4)	(5)	(6)
Post × Cross-state × Distressed	0.0561*	0.0623*	-0.000558	0.00203	0.00675	-0.000438
	(1.66)	(1.82)	(-0.05)	(0.04)	(0.15)	(-0.03)
Post × Cross-state	-0.0579***	-0.0546***	-0.0144***	-0.0566***	-0.0549***	-0.0139*
	(-3.01)	(-2.68)	(-2.59)	(-3.75)	(-3.57)	(-1.70)
Post	0.0395***	0.0321***	0.0310***	0.0390***	0.0336***	0.0252***
	(3.67)	(2.95)	(7.01)	(4.76)	(4.06)	(7.02)
Post × Distressed	0.00864	0.00827	0.00311	-0.0132	-0.0133	-0.000751
	(0.48)	(0.45)	(0.57)	(-0.63)	(-0.64)	(-0.14)
Size (Acquirer)	-0.0975***	-0.0946***	-0.0235*	-0.0920***	-0.0658**	-0.0620***
	(-3.16)	(-3.01)	(-1.77)	(-3.01)	(-2.13)	(-4.19)
$Size^2$ (Acquirer)	0.00423***	0.00390***	0.00149***	0.00422***	0.00298**	0.00289***
	(3.32)	(3.00)	(2.81)	(3.38)	(2.34)	(4.71)
Size (Target)	-0.197***	-0.150***	-0.148***	-0.217***	-0.176***	-0.157***
	(-4.65)	(-3.53)	(-7.95)	(-6.08)	(-5.04)	(-8.08)
$Size^2$ (Target)	0.00614***	0.00450**	0.00493***	0.00730***	0.00595***	0.00569***
	(3.15)	(2.28)	(5.86)	(4.28)	(3.54)	(6.16)

Average total distance (Acquirer)	0.255***			0.267***		
	(11.60)			(13.33)		
Average total distance (Target)	0.246***			0.245***		
	(10.92)			(12.72)		
Average asset distance (Acquirer)		0.253***			0.241***	
		(10.26)			(10.59)	
Average asset distance (Target)		0.245***			0.242***	
		(9.56)			(11.60)	
Average liability distance (Acquirer)			0.276***			0.337***
			(16.25)			(21.87)
Average liability distance (Target)			0.247***			0.243***
			(14.77)			(17.26)
No banks (Target)	0.0000896	0.000130	-0.000151	-0.0000816	-0.000113	0.0000492
	(0.42)	(0.61)	(-1.56)	(-0.60)	(-0.79)	(1.00)
No banks (Acquirer)	-0.000265	-0.000283	-0.0000772	-0.000227	-0.000206	-0.0000987*
	(-1.36)	(-1.43)	(-0.82)	(-1.63)	(-1.44)	(-1.76)
Constant	8.51e-12	-1.72e-11	-9.03e-12	3.81e-13	2.39e-11	-4.66e-11
	(0.00)	(-0.00)	(-0.00)	(0.00)	(0.00)	(-0.00)
Observations	66817	66817	66817	82971	82971	82971
Adjusted R^2	0.092	0.082	0.099	0.079	0.063	0.107
Merger effects	Yes	Yes	Yes	Yes	Yes	Yes
State of acquirer × time effects	Yes	Yes	Yes	Yes	Yes	Yes
State of target × time effects	Yes	Yes	Yes	Yes	Yes	Yes

Table 3.8: Probit regressions of the likelihood of merger

The dependent variable in all regressions is a dummy variable indicating that a pair of banks merged. Distressed is a dummy, which indicates that there was regulatory involvement in the merger. Total distance is the Euclidean distance between all financial ratios, as listed in Table 3.A1 in the Appendix, of a pair of banks. Asset distance and Liability distance are the Euclidean distances between asset-side and liability-side financial ratios, respectively, as listed in Table 3.A1 in the Appendix, of a pair of banks. t statistics are shown in parentheses. *, ** and *** indicate significance at the 10, 5 and 1 percent level.

	(1)	(2)	(3)
Total Distance * Distressed	0.711*		
	-1.84		
Total Distance	-0.432***		
	(-3.38)		
Asset Distance * Distressed		0.858**	
		-2.09	
Asset Distance		-0.556***	
		(-4.12)	
Liability Distance * Distressed			-0.295
			(-0.45)
Liability Distance			0.568***
			-3.45
Distressed	-0.461**	-0.500**	-0.111
	(-2.29)	(-2.50)	(-0.97)
Constant	-2.269***	-2.231***	-2.521***
	(-40.01)	(-39.93)	(-85.49)
Observations	44860	44860	44860

Chapter 4

The Interaction of Bank Regulation and Taxation

Abstract The tax benefit of interest deductibility encourages debt financing, but regulatory and market constraints create dependency between bank leverage and asset risk. Using a large international sample of banks in this paper I find that banks located in high-tax countries have higher leverage and lower average asset risk-weights. I argue that this finding is induced by capital regulation. While the estimated overall effect of taxation on bank risk is modest, it induces significant portfolio reallocation toward less lending. These results suggest that any elimination of the tax bias towards debt may not bring the expected benefits for bank stability.

4.1. Introduction

There is consensus among researchers that bank capital structure is an important determinant of financial stability as better capitalized banks tend to be more resilient. This realization motivates a large literature trying to understand the determinants of bank capital structure, one of which is corporate income taxation (CIT). A tax bias arises, because in most countries debt financing has a tax advantage through interest deductibility relative to equity financing. It is not surprising then, that taxation was identified as one of the possible sources that might have indirectly contributed to the financial crisis of 2007 and 2008 through its impact on bank leverage (De Mooij, 2012; Slemrod, 2009; Turner, 2010). While there is some recent work assessing the effect of taxation on bank capital structure (Keen and de Mooij, 2012; De Mooij et al., 2013; Gu et al., 2012; Hemmelgarn and Teichmann, 2013), the implications of corporate income taxation have not been fully explored for bank risk. In particular, most papers neglect the effect of taxation on bank portfolio risk, with one notable exception by Devereux et al. (2013). In this paper I estimate the impact of corporate income taxation on bank leverage and portfolio risk, taking into account that they might be jointly determined.

A main reason for the interrelatedness of bank leverage and portfolio risk is bank regulation. This directly forces weakly capitalized banks to trade off leverage and asset risk in order to comply with the minimum capital requirements under the widely adopted Basel rules, defined as the ratio of qualifying bank equity and risk weighted assets. This trade-off may be present even if the constraint is not binding, as long as banks want to hold precautionary capital buffers in order to avoid non-compliance costs as a result of unexpectedly falling below the regulatory minimum requirement.[22] The second aim of this paper is to shed light on whether capital regulation can explain how corporate income taxation affects leverage and portfolio risk.

The main findings of this paper are as follows. Firstly, I find that in countries where CIT rates are higher banks have higher leverage ratios and that in these countries banks hold less risky assets. Using a data set that includes 17,003 banks from 71 countries and spans the years 1997-2011, I find 0.9-1.1 percentage points higher leverage ratios on average (conditional on a wide range of bank and country characteristics) for banks located in countries with 10 percentage point higher tax rates. These estimates lie in the range found by previous papers using bank level data (0.14-0.31 in Keen and de Mooij (2012) and De Mooij et al. (2013) and 0.1 in Hemmelgarn and Teichmann (2013)) and country level data (0.04-0.09 in De Mooij et al. (2013)). As a novelty, I also find that a 10 percentage point increase in the tax rate is associated with a 2-7 percentage point decrease of the average risk-weighted assets (RWA) of banks. This association cannot be fully attributed to risk-weight manipulation, since as I show, CIT also has a negative relationship with the volume of relatively risky bank lending and a positive relationship with portfolio quality.

Next, I show that the negative association between asset risk and CIT is stronger in countries where regulators are more stringent and for banks that are more constrained by regulatory pressure to meet capital requirements. Furthermore, I also explore how the leverage and asset volatility of non-financial firms is related to CIT and I find a positive association in both relations. Since non-financial firms are not subject to risk-dependent

[22]Banks may also want to voluntarily trade off leverage and asset risk in order to reduce bankruptcy costs, as in Allen et al. (2014). Banks, as well as non-financial firms, choose a capital structure that balances the marginal costs of equity financing with the marginal expected bankruptcy costs.

capital constraints they do not seem to be forced to reduce asset risk in high-tax countries to be able to lever up. These results suggest that the regulatory constraint for banks is operational, which is in contrast with other papers that argue that the regulatory constraint is weak, for example, Gropp and Heider (2010).

Finally, looking at the overall impact of taxation on bank stability, I find no evidence that corporate income taxation makes banks less safe. In fact, regressions of banks' Z-score –a measure of the likelihood of bank failure– on CIT suggest a risk reducing effect of taxes, but the results are not robust. Overall, the results suggest that the elimination of the debt bias may not bring the expected benefits, since banks may substitute leverage risk for asset risk.

This paper bridges and extends two strands of literature. The first of these aims at quantifying the effect of CIT on bank capitalization. This literature is itself part of a larger research agenda, which seeks to understand whether banks have optimal capital ratios and if so, what their determinants are. Theoretical work includes Orgler and Taggart (1983), Myers and Rajan (1998), Calomiris and Kahn (1991), Diamond and Rajan (2000), and Allen et al. (2011). Empirical evidence is consistent with theories of optimal capital structure (Schaeck and Čihák, 2012; Flannery and Rangan, 2008; Marcus, 1983); and the literature has also converged to a set of factors that are reliable determinants of bank (and non-financial firm) leverage (c.f. Gropp and Heider, 2010; Frank and Goyal, 2009; Berger et al., 2008). While evidence on the tax bias is abundant, most papers discard financial firms from the analysis (see e.g. the reviews of Graham, 2006; Auerbach, 2002).

There are a few recent papers that focus on banks. Keen and de Mooij (2012) find a long run CIT impact on bank leverage close to what the literature covering non-financial firms has found. Hemmelgarn and Teichmann (2013) look at how banks change their leverage, dividend policy and earnings management in reaction to tax rate changes and find a positive, but somewhat lower tax elasticity of leverage for banks. De Mooij et al. (2013) go one step further and estimate the effect of CIT on the likelihood of financial crises through increased leverage. Gu et al. (2012) concentrate on multinational banks' cross-boarder debt-shifting incentives. Building on Huizinga et al. (2008), who estimated similar effects using a sample of non-financial firms, they find that, beside local tax rates, home-host country tax rate differences induce banks to allocate more capital to subsidiaries where CIT rates are lower. A common feature of these papers is that they treat asset risk as an exogenous variable[23], and little or no attention is paid to the simultaneous determination of asset risk and leverage. This paper extends this literature by treating both leverage and risk as endogenous variables.

Closest to this paper is Devereux et al. (2013), who estimate the impact of levies imposed on bank liabilities in a number of European countries. As the present paper, these authors estimate leverage as well as asset portfolio risk regressions and find that higher levies induced banks to reduce leverage and increase asset risk; an analogous result to those presented here. There are a number of differences that distinguish our papers. While Devereux et al. (2013) look at levies imposed on liabilities, this paper uses corporate income taxes, which are more universal. Also, their sample consists of large European banks, while my sample covers a significantly larger range of countries and banks and a longer sample period. Using cross-country variation in the regulatory environment I can thus investigate the interaction between regulation and taxation more deeply, allowing me to identify the source of the trade-off between leverage and asset risk.

This paper also contributes to the literature trying to understand how banks coordinate capital and risk adjustments and what role capital regulation plays in this relationship. Using a partial adjustment model with simultaneous equations for capital and risk adjustments, originally developed by Shrieves and Dahl (1992) and then applied by Jacques and Nigro (1997), Aggarwal and Jacques (2001), Rime (2001), Heid et al. (2004) and Jokipii and Milne (2011), this literature generally finds a positive relationship between the short run adjustments of capital and asset risk. I extend this literature by adding taxes to the determinants of target leverage and portfolio risk and, to my knowledge, for the first time the simultaneous equations/partial adjustment model is applied to an international sample of banks.

Recent work has also been done on the determinants of banks' RWA density (risk weighted assets to total assets). Le Leslé and Avramova (2012) list several bank and country level factors that can potentially influence RWA density. Mariathasan and Merrouche (2013) provide evidence that banks regulated under Basel II took advantage of

[23]Keen and de Mooij (2012) treat risk as an exogenous variable in their theoretical model, and as an endogenous explanatory variable in their empirical work, but they neglect the effects of CIT on bank risk.

advanced methods to calculate regulatory capital, which allowed them to lower their capitalization levels. This eventually led to an increased likelihood of failure during the financial crisis. My paper adds to our understanding of what determines banks' management of risk weighted assets.

I proceed as follows. In section 4.2 I motivate the hypotheses of this paper and in section 4.3 I explain the applied econometric approach. In section 4.4 I describe the data used in the regressions. In section 4.5 I show that leverage and asset risk are differently related to CIT and in section 4.6 I explore how regulation interacts with taxation and subsequently look at non-financial firms' leverage and asset volatility. Section 4.7 presents results of regressions on overall bank risk and section 4.8 discusses the results and concludes.

4.2. Hypotheses and theoretical framework

In this section I motivate the hypotheses with the help of a few simple accounting relationships and a simplified regulatory constraint akin to what is applied under the Basel regime. The key feature is that regulatory requirements are defined by leverage and a regulatory measure of bank risk.

4.2.1. The interaction between capital regulation and taxation

For simplicity let us assume that there are only two types of liabilities, equity capital K and debt D, and N types of assets, denoted by $A_i, i \in \{1 \dots N\}$. Each asset type's risk is measured by a (regulatory) risk weight ω_i. The following accounting identity must hold at all times:

$$A = \sum_i A_i = K + D, \tag{4.1}$$

where A denotes total assets. The leverage ratio is then defined as $l = D/A$ and portfolio risk as $r = \sum_i \omega_i A_i / A$.

Banks are required to hold at least a certain amount of capital. This constraint can be expressed as:

$$k \leq \frac{K}{\sum_i \omega_i A_i} = \frac{K}{\sum A_i} \Big/ \frac{\sum_i \omega_i A_i}{\sum A_i} = \frac{1-l}{r}, \tag{4.2}$$

where k is the minimum capital adequacy requirement. This form of capital constraint is similar to that implemented under the Basel accords. Under Basel I and the basic forms of Basel II banks are required to hold at least 8% eligible capital relative to risk weighted assets.[24] Notice that a binding capital requirement constraint implies that leverage l and asset risk r become substitutes in the sense that banks can choose higher leverage levels by lowering asset risk.

Later, in the econometric part I assume that banks choose a target leverage ratio. While in a Modigliani-Miller world target leverage is irrelevant, in reality firms (including banks) balance the costs and benefits associated with deviations from the MM world. Such deviations may arise as a result of agency problems, the tax bias and bankruptcy costs, leading to an intermediate level of optimal leverage. In particular, corporate income taxes are expected to increase the optimal debt level, because of the tax benefits of debt as a result of interest deductibility.

Similarly, I assume that banks have a target asset risk level. Factors that can be related to risk taking include firm governance characteristics and the ownership structure (by influencing the type and severity of agency problems within firms), size (through too-big-to-fail subsidies), the business mix, and the regulatory environment. The optimal asset risk level may also depend on taxes. The main channel taxes are expected to influence bank risk taking works through banks' profitability. The literature establishes a link between risk taking and bank charter value due to moral hazard. Since corporate income taxes reduce profitability, banks might respond by taking more overall risk, possibly by increasing asset risk.

To summarize, the main hypothesis of this paper is that banks choose higher levels of leverage in countries where CIT rates are higher; and reduce asset risk in order to

[24] I do not distinguish between different forms of eligible regulatory capital. Under Basel I and II Tier I capital comprises mostly common equity, while Tier II capital denotes various forms of hybrid capital elements, such as subordinated debt. Hybrid capital forms have the benefit that interest repayments on them are generally interest deductible, while they qualify as regulatory capital – up to a certain limit. As a result, as Keen and de Mooij (2012) show, banks have a tendency to choose the maximum amount of hybrid capital funding up to the allowed limit to meet regulatory requirements, the level of which is not effected by CIT. Therefore, abstracting from this capital element has little bearing on the estimated tax effects on bank capital structure.

alleviate regulatory pressure on their capitalization.

4.3. Econometric approach

From the previous discussion it follows that equilibrium leverage and asset risk are jointly determined. Instead of attempting to estimate structural equations of leverage and asset risk I estimate reduced form, static and dynamic, regressions to establish the relationship between tax rates between leverage and asset risk.

4.3.1. Long run estimates of tax elasticities

I obtain baseline OLS estimates of the long run reduced form tax elasticities by estimating the following static regressions:

$$\overline{y}_{ij} = \alpha + \gamma \overline{CIT}_i + \delta \overline{X}_{ij} + \lambda \overline{Y}_i + \varepsilon_{ij}, \tag{4.3}$$

where y_{ijt} is either leverage or one of the risk/asset composition measures of bank j in country i in year t, CIT_{it} is the statutory corporate income tax rate, X_{ijt} and Y_{it} are collections of bank and country level control variables, respectively, ε_{ij} is an error term, and upper bars denote time-averaged variables. The baseline risk measure is risk-weighted assets over total assets (r in the previous section) and I employ two additional asset composition variables to try to break down the adjustment of risk-weighted assets to total assets into a "quality" and a "quantity" effect. This separation rests on the observation that banks hold large amounts of government securities, which fetch zero or low risk weights. The "quality" effect then refers to the riskiness of the risky asset portfolio, while the "quantity" effect relates to the size of the risky portfolio.

Unfortunately, banks do not report risk weights separately for different asset types, thus I cannot measure the impact of taxation on risk weights of different asset classes directly. Instead, I proxy the average risk weight of risky assets by the share of non-performing loans, while the loans-to-assets ratio proxies the size of banks' risky portfolio.[25] These measures can also be thought of as alternative measures of bank asset risk.

[25] This is a precise measurement in the special case when there are only two asset types, a risky asset with risk weight ω_r and a riskless asset $\omega_i = 0$. Then asset risk is $r = \omega_r A_r / A$ which depends on the amount of risky assets and the risk weight.

There is a tradition of proxying bank risk with the share of non-performing loans. There is also recent evidence that banks that had higher loans to assets ratios performed worse during the financial crises in 2007 and 2008 (Beltratti and Stulz, 2012).

4.3.2. Partial adjustment and simultaneous regressions

It is common in the literature to assume that capital structure adjustment is not immediate (c.f. Gropp and Heider, 2010; Berger et al., 2008). Following these papers I estimate dynamic versions of (4.3), which allow for sluggish adjustment of the dependent variables. The underlying assumption is that banks have leverage and risk targets and in each period they aim to close a constant fraction of the gap between the target and actual leverage and risk levels, if they differ. I explain these assumptions in section 4.9.1 of the Appendix in greater detail. The estimated partial adjustment model is:

$$y_{ijt} = \alpha + \beta y_{ijt-1} + \gamma CIT_{it} + \delta X_{ijt} + \lambda Y_{it} + \eta_t + \mu_{ij} + \varepsilon_{ijt}, \tag{4.4}$$

where ε_{ijt} is a potentially serially correlated idiosyncratic error term. The OLS and within estimators yield biased estimates of the coefficients in (4.4) because y_{ijt-1} is correlated with the fixed effects in the error term, which cannot be removed by simple demeaning. To overcome this difficulty I employ the system-GMM estimator developed by Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998). This estimator eliminates bank fixed effects through first differencing, while the resulting endogeneity due to differencing is resolved by instrumenting with lags. The advantage of the GMM estimator is that it exploits both the time and cross-sectional variations of the data, while still controlling for unobserved time-invariant heterogeneity. I employ the two-step GMM estimator to allow for a non-spherical error covariance structure and calculate standard errors clustered at the country level. Furthermore, the finite sample correction to the two-step covariance matrix derived by Windmeijer (2005) is applied.

4.4. Data

I construct an unbalanced dataset spanning the period 1997-2011 covering 17,003 banks from 71 countries, based on data from Bankscope of Bureau van Dijk. This database contains bank balance sheet and income statement data from annual reports. In order to have a more homogenous sample I exclude financial institutions other than commercial banks, saving banks, and cooperative banks (e.g. investment banks and mortgage banks). Next, I restrict the sample to unconsolidated balance sheet data. This reflects that corporate income taxes are country specific, while consolidated accounting data are often multinational. To reduce the bias due to misreporting and outliers I winsorize all bank level variables at the 1% and 99% levels. Additionally, I remove all banks from the database with negative equity, as these banks might exhibit exceptional balance sheet ratios.

This leaves 148 608 bank-year observations, but due to limitations of Bankscope the sample size drops to 106 688 bank-year observations in the RWA density regressions, and to 103 624 bank-year observations in the regressions on the share of non-performing loans. About two thirds of the banks in the sample are located in the United States, which potentially has a sample bias effect on the results if US banks respond to taxation differently from banks in other countries. To avoid drawing conclusions from potentially biased results, I also report the main results using a restricted sample excluding US banks.

Table 4.1 shows summary statistics for all variables and the Appendix provides details about the definition and data sources of the variables. The main dependent variables are the *Leverage* ratio, which is defined as liabilities over total assets and *RWA* density, defined as risk weighted assets to total assets. Additionally, I replace *RWA* with two alternative measures of asset composition: *Loans* (relative to total assets); and *NPL*, the natural logarithm of the share of non-performing loans to total loans.[26] These variables are closely related to bank asset risk. While *Loans* measures banks' exposure to risky assets relative to other, less risky assets, such as government bonds, *NPL* is a measure of the quality of banks' loan portfolios.

Table 4.1 shows that *Leverage* has a mean of 0.89. Mean *RWA* density is 0.68, close to the mean of *Loans* at 0.62. There is a close association between RWA density and the loan ratio as shown by the high correlation between them (0.75, see Table 4.2). The share of non-performing loans (before taking logarithm) is close to 3% with a standard deviation

[26] I took the logarithm of the share of non-performing loans, because it is has a highly skewed distribution.

of 0.04. I assess the overall effects of corporate income taxation on bank risk using the natural logarithm of Z-score. Z-score measures the losses required to entirely wipe out a bank's equity capital and is defined as $Z - score = \log[(K/A + ROA)\,/\sigma(ROA)]$, where $\sigma(ROA)$ is the standard deviation of return on assets and is calculated over the full sample period. *Z-score* is thus a measure of distance to default, higher values reflecting safer banks. Log is taken of Z-score because it has a highly skewed distribution.

The tax variable (CIT) is the top statutory corporate income tax rate in the country of a bank's residency. While the effective marginal tax rate is a better measure in theory (Graham, 2000), in practice it is difficult to assemble for a multi-country analysis such as this. There are also good reasons why the top statutory tax rate is a good approximation of banks' effective marginal tax rate. First, banks are typically large companies, so the progressivity of the tax schedule is unlikely to be relevant. Second, the present value of the tax benefit of an additional unit of debt declines when a bank is unlikely to be able to take advantage of the tax deduction because of a future possible bankruptcy. However, banks enjoy significant bailout guarantees and thus the difference between the effective marginal tax rate and the statutory rate is expected to be smaller for banks than for non-financial companies.

The main sources of the statutory corporate income tax rates are the OECD database and, in case of non-OECD countries, the KPMG Corporate and Indirect Tax Surveys 2007, 2010 and 2011, which cover the period between 1993 and 2011. The average tax rate is 38.6%. This relatively high figure reflects that the sample contains a large number of banks located in the United States, Germany and Japan, all of which have high CIT rates (on average 39.3%, 39.5% and 33.3%, respectively).

I control for a range of bank and country level factors related to bank leverage and assets risk. Since I perform reduced form estimations, I include all control variables in both the leverage and risk equations. Bank size is commonly found to be positively related to leverage, which is explained by large banks' better risk diversification possibilities, better investment opportunities and access to debt capital. *Size* is taken to be the natural logarithm of the book value of total assets and to allow for a non-linear effect I also include the square of this variable. I also control for bank profitability by including two variables, *net interest margin* and the return on average assets (ROA): on the one hand firms may choose riskier asset portfolios in return for higher expected returns, on the other hand positive retained earnings improve banks' capitalization keeping other factors constant. *Fee income*, defined as non-interest income over total operating income, and *Wholesale funding*, measured by the ratio of non-deposit funding to total short term funding, control for income diversification and access to whole-sale funding. Both factors are shown to change the risk/return trade-off that banks face by Demirgüç-Kunt and Huizinga (2010). DeAngelo and Masulis (1980) show that non-debt tax shields, such as depreciation and investment tax credits, can crowd out the tax benefits of debt. To control for differences in access to non-debt tax shields I include *Non-interest expenses* relative to total assets, a proxy also used by Gu et al. (2012). The final bank level control variable in the baseline specification is *Market share*, the share of total assets relative to nationwide total bank assets, a proxy for market power. A higher market power may increase a bank's charter value, which reduces risk taking incentives. Alternatively, it can lead to increased risk taking by the bank's borrowers, which increases bank risk.

In robustness checks I also make use of the ownership data of Bankscope as well as the database assembled by Claessens and van Horen (2014) in order to control for the possibility of international debt-shifting by multinational banks. I create three variables: *CIT diff (Local - owner)* is the difference between tax rates applicable to the bank and its owner: for domestically owned banks it is zero (as well as for banks without ownership data), while for banks owned by a foreign parent it is positive if the local tax rate is higher than in the country where the parent bank is headquartered. In a similar fashion *CIT diff (Local - frgn subsidiary)* is calculated as the difference between the local and foreign tax rates, but this time the latter is taken to be the average (unweighted) tax rate of the countries where the subsidiaries are located (domestic subsidiaries are excluded). Subsidiary data is taken from Bankscope, and not from Claessens and van Horen (2014), since the latter does not contain information on subsidiaries (only on ultimate owners). A subsidiary is taken to be owned by a parent company if it has an ultimate ownership larger than 50%. Bankscope does not contain historic ownership data, therefore I assume that subsidiary ownership did not change over the sample period (an assumption also made by Gu et al. (2012)).[27] Finally, I include a dummy variable (*No ownership data dummy*) indicating if a bank is not in the Claessens and van Horen (2014) database. This

[27]No dummy variable is created to indicate missing subsidiary data as it is not known if a bank truly does not have any subsidiaries or it only appears so because of missing data. Furthermore the sample contains only 24 observations where a bank has exclusively domestic subsidiaries.

variable controls for the possibility that the availability of ownership data is correlated with the tax rate difference between owners and subsidiaries.

In addition to the bank level control variables I also add country level macroeconomic controls. *RGDP growth* controls for the cyclical variation of leverage and risk related to business cycle fluctuations. Leverage is expected to be procyclical (high in upturns, low in downturns) because various constraints, such as collateral and regulatory constraints, are tighter during downturns (Adrian and Shin, 2010; Geanakoplos, 2010). Asset risk is also expected to be larger in recessions, when borrowers have lower net worth or because risk may be overestimated. *GDP per capita*, calculated on a PPP basis, controls for differences in the economic development between countries, which might be correlated with financial and capital market development. The consumer price index (*CPI*) serves as a proxy for expected inflation. The real value of tax deductions (positively) depends on expected inflation, thus it is an important control variable (as confirmed by Frank and Goyal, 2009), with a positive expected effect on leverage. *Government debt to GDP* serves to control for "financial repression" and/or banks' incentives to load on highly indebted governments' debt. This channel suggests a negative relationship between government indebtedness and *RWA*, because sovereign debt fetches a low regulatory risk weight under Basel I and II. The last macroeconomic control variable is the nominal *Exchange rate change*, which has been shown to affect portfolio risk (Bock and Demyanets, 2012). A large nominal exchange rate depreciation might reduce borrowers' ability to service debt denominated in foreign currencies, which –ceteris paribus– worsens portfolio quality. On the contrary, depreciation might be beneficial, if this strengthens international competitiveness and improves corporate profits. *RGDP growth*, *GDP per capita*, *Government debt/GDP*, *CPI* and *Exchange rate change* figures were taken form the World Economic Outlook database. *Aggregate credit* controls for loan demand, which is calculated as the sum of gross loans of all other banks in the country, normalized by the sum of total assets. It is common that corporate income taxes are the same for financial and non-financial companies, therefore taxes might be correlated with loan demand (through the same tax-shield effect or by influencing firm profitability) as well as bank leverage and risk. Since loans are generally riskier than other risky assets, such as government bonds, an increase in loan demand may lead to higher RWA density through an increased share of loans in total assets.

Next, I control for the regulatory environment by including minimum *Capital requirements* and two other indicators from Barth et al. (2001). The first, *Capital stringency* is a measure of regulatory oversight of how banks calculate capital, which ranges between 0 and 9, with higher values indicating more stringency. *Activity restrictions* is a variable that measures regulatory restrictions on certain bank activities, such as securities market, insurance, real estate activities and the ownership of non-financial firms, on a scale from 4 to 16, with higher values indicating more restrictions. These regulatory controls are commonly used in the bank risk taking and capital regulation literature (see Laeven and Levine, 2009, for example). On the one hand stricter regulation may result in less levered banks and with less risky assets, reflecting the regulator's preferences for a more stable banking sector. On the other hand, bankers may compensate for the loss in utility as a result of regulation by increasing risk taking, which may lead to higher leverage and/or higher asset risk. Thus, the impact of regulation is ambiguous ex ante. Bank regulation data are obtained from the World Bank's Bank Regulation and Supervision Survey database. The survey comprises four waves, 2001, 2003, and 2007, 2011 and I replace missing values of interim years by the values of subsequent years (so, for instance, observations of 2009 are taken from the last wave).

In some specifications I include a dummy variable *Buffer dummy*, which takes the value of 1 if a bank has on average over the sample period a capital buffer larger than the median buffer (calculated over the full sample). I also include the dummy variable *Basel II* indicating whether in a given year and a given country the Basel II guidelines were implemented and in effect. This dummy serves to control for the possibility that Basel II allows for a more lenient way of calculating regulatory capital. Under Basel II banks can opt for internal models to determine risk weights, which opens the door to regulatory arbitrage and risk-weight manipulation through model optimization (Mariathasan and Merrouche, 2013). The dummy is constructed from data from the BIS progress reports on the implementation of the Basel regulatory framework.[28] Finally, I control for shareholder protection with *Creditor rights*, an index of statutory rights of shareholders from Djankov et al. (2007). The index ranges from zero to four and higher values indicate

[28] The first year in which this variable is nonzero is 2007, when all EU Member States introduced the new regulation, along with few other countries. Some countries, however, waited with the implementation, the US for instance was a slow mover with an adoption year of 2009. By 2011 forty-four countries had adopted the Basel II rules in the sample.

more creditor protection. It is expected to be positively related with bank loans and bank leverage, since creditors are more willing to lend when they have more powers in case of bankruptcy.

4.5. Results – the relationship between taxes and leverage and asset risk

In this section I present regression results showing that banks have higher leverage and lower asset risk in high-tax countries. I also explore how robust these observations are to changing the asset risk measure and I employ various other robustness checks.

4.5.1. Leverage regressions

The left panel of Table 4.3 shows the baseline regressions of bank leverage. Column (1) reports the between estimates, using the full sample. The estimate of the *CIT* coefficient is significant, but at 0.09 it is considerably smaller than what earlier literature found using similar bank level data (e.g. Keen and de Mooij (2012) and De Mooij et al. (2013)). These papers find long run tax effects on leverage in the range of 0.14-0.31. In unreported regressions, which include only the control variables used by the mentioned studies (*Size*, $Size^2$, *ROA*, *CPI*, *RGDP growth*), I find that the difference comes mostly from the inclusion of additional control variables. For example, dropping the dummy *Basel II* increases the coefficient estimate of *CIT* from 0.09 to 0.21. However, dropping any other further control variable does not change this coefficient estimate by more than 0.02.

The control variables have generally the signs found in other studies: *Size* is positively and significantly related to leverage in a non-linear way. *Net interest margin* is also significant and obtains a negative coefficient. Similarly, *ROA* obtains a negative, but insignificant coefficient. Thus, banks seem to use retained earnings to recapitalize. The risk characteristics proxies, *Fee income* and *Wholesale funding*, are negatively related to leverage, which is consistent with a substitution effect between various risk types. The non-debt tax-credit proxy, *Non-interest expenses*, has a significant, negative coefficient, as in Gu et al. (2012). Finally, *Market share* is positively related to leverage, which may be because banks can borrow against the net present value of their monopoly rents. At the country level higher *Capital requirements* and *Activity restrictions* reduce, stronger *creditor rights* enhance debt financing, as expected. *Basel II* and *GDP growth* enter with negative and significant coefficients, while *Aggregate credit* enters with a positive sign.

In column (2) I follow the literature on bank capital structure, and estimate a dynamic panel model (equation (4.4) in section 4.3) with the system GMM estimator. The estimated short run impact is 0.05, significant at 1%, which is about half of what Keen and de Mooij (2012) find. They, however, find a slower adjustment speed than I do: the estimate of the coefficient of the lagged dependent variable in column (2) is 0.58, significant at 1%. These coefficients combine into a long run marginal effect of 0.11 ($= \gamma/(1-\beta) = 0.05/(1-0.58)$), which is close to the long run estimate using the between estimator in column (1). A 10% increase in the statutory income tax rate is thus associated with an expected increase in bank leverage by about 0.9-1.1 percentage points.

4.5.2. RWA density regressions

The right panel of Table 4.3 shows the results of regressions on risk weighted assets to total assets. The regressions are analogous to the leverage regressions in columns (1)-(2). In column (3) the OLS regression on the time-averaged variables yields a result that is consistent with the buffer theory of bank capital: *CIT* has a negative coefficient of -0.20, significant at the 1% level. A 10 percentage point higher tax rate is thus associated with an expected reduction in the long run of about two percentage points, which seems small compared to the average level of 67%, but it could be significant for the real economy at the aggregate level through its effect on credit supply.

Next, in column (4) I allow for sluggish adjustment using the system GMM estimator, also controlling for time and bank fixed effects. Along with other time-invariant bank characteristics, bank fixed effects should control for corporate governance performance and ownership structure, which have been shown to be related to bank risk-taking (Laeven and Levine, 2009). To estimate this regression I restricted the sample to exclude years up to 2003, because almost all RWA observations prior to 2004 were submitted by US banks. The rate of adjustment is slow, banks close only about 16% ($= 1 - 0.84$) of the gap between target and actual RWA density per year. The short run impact of *CIT* is -0.11, which is significant at 5%. This translates into an expected long run elasticity of -0.70, significant at 10%, about three times the between estimate. Overall, Table 4.3 suggests that banks have lower asset risk when taxes are higher.

Most control variables obtain the expected signs. *Size* is positively associated with risk, which might reflect moral hazard due to too-big-to-fail benefits; but there are diminishing returns as suggested by the significant, negative coefficient of the quadratic term. *Net interest margin* has a positive coefficient, significant in both regressions. This might be because banks charge higher interest rates for more risky loans. *ROA*, on the other hand has a negative coefficient, which could be the result of moral hazard, to the extent that smaller profitability reduces charter value. *Fee income* is negatively associated with *RWA*, perhaps signaling that more income diversification is accompanied by more risk taking (consistent with mean/variance optimization).

The negative and significant coefficient of *Basel II* is evidence of banks reducing risk weights through the adoption of risk models allowed by Basel II. *Exchange rate change* has a significant, negative impact on bank risk, possibly due to a lower income to debt service ratio for borrowers indebted in foreign currency. Loan demand is positively associated with RWA density, probably as a result of increased lending relative to investing in low-risk securities. Contrary to the expectations, government indebtedness enters with a positive sign. This could be, however, explained if a larger supply of government securities relaxes collateral constraints by providing safe assets, which leads to higher aggregate liquidity and loan supply.

4.5.3. Robustness: restricted samples, ownership structure and simultaneous regressions estimation

Table 4.4 presents the results of further robustness checks. First, I restrict the sample to pre-crisis years (up to 2006) and reestimate regressions (1) and (3) of Table 4.3. It is conceivable that during crisis periods other factors influencing banks' capital structure become more important relative to tax incentives. Indeed, in regression (1), when the dependent variable is *Leverage*, the long run marginal effect of CIT is 0.16, almost twice as large as the baseline between estimate. Next, *CIT* obtains a negative and significant coefficient in regression (2) using the between estimator. This is in between the estimates of the between and GMM regressions of Table 4.3.

To deal with the overrepresentation of US banks in the sample I also reestimate the baseline between estimates excluding US banks. Columns (3) and (4) show the corresponding results. In the leverage regression the coefficient on *CIT* is about the same size as when run on the full sample (0.11 versus 0.9). In the RWA regressions *CIT* remains negative at -0.08, but it is not significant anymore.

Multinational banks have an incentive to shift debt to subsidiaries located in high-tax countries. Regressions (5) and (6) attempt to control for the possibility that such debt shifting correlates with risk incentives, which could potentially bias the results. To that end I include *CIT diff (Local - frgn subsidiary)*, which is the difference between the CIT rate applicable in the country of residency of a bank and the average CIT rate of its subsidiaries. Similarly, I add the difference between the local CIT rate and the CIT rate of the country of the parent bank (which is zero in case of same country parent banks). I also include a dummy indicating if no ownership data is available. The main results do not change as the estimated long run marginal tax elasticity of debt is still around 0.8 and significant, while an offsetting elasticity is measured for *RWA* at -0.2, also significant. The tax rate differences do not enter the regressions with significant coefficients.

The regressions presented so far were estimated as single equations. Next, I estimate the leverage and RWA regressions as a system of simultaneous equations, which yields more efficient estimates in theory. The model I estimate builds on Shrieves and Dahl (1992) and is formulated as:

$$\Delta Leverage_{ijt} = a_1 Leverage_{ijt-1} + b_1 \Delta RWA_{ijt} + d_1 CIT_{it} + e_1 X_{ijt} + f_1 Y_{it} + \eta_t + \upsilon_{ijt} \tag{4.5}$$

$$\Delta RWA_{ijt} = a_2 RWA_{ijt-1} + b_2 \Delta Leverage_{ijt} + d_2 CIT_{it} + e_2 X_{ijt} + f_2 Y_{it} + \theta_t + \zeta_{ijt}. \tag{4.6}$$

In these equations the adjustment of leverage is allowed to depend on the simultaneous adjustment of risk and vice versa, which is captured by the terms b_1 and b_2. X_{ijt} and Y_{it} are bank and country level determinants of leverage and asset risk, while η_t, θ_t, are time effects and υ_{ijt} are ζ_{ijt} possibly correlated disturbance terms.

The results of estimating equations (4.5) and (4.6) are presented in columns (7) and (8) of Table 4.4. In the leverage regression the lag of leverage obtains a coefficient of

-0.39, which yields a somewhat slower speed of adjustment than the single equation GMM estimate of regression (2) in Table 4.3. Similarly, the speed of adjustment of RWA density in the 3SLS model is also smaller (0.13) than the single equation GMM estimate of regression (6) in Table 4.3 ($1 - 0.85 = 0.15$).

Next, the long run marginal CIT effect on leverage is 0.07 ($= -b_1/a_1 = -0.0268/(-0.386)$), significant at 5%, somewhat smaller then the single equation OLS estimate (at 0.09 in regression 1, Table 4.3). The long run *RWA* elasticity is -0.76 ($= -b_2/a_2 = 0.099/(-0.130)$), significant at one percent, which is also similar in magnitude to the baseline OLS and GMM estimates of -0.20 and -0.70 (regressions (3) and (4) in Table 4.3), respectively.

Turning to contemporaneous adjustments in risk and leverage, banks respond to a positive shock to *RWA* by contemporaneously reducing leverage as evidenced by the significant, negative coefficient of *D.RWA* in column (7), perhaps to buffer themselves against expected losses or to maintain compliance with capital requirements. Interestingly, the positive coefficient of *D.Leverage* in column (8) suggests that banks respond to an increase in leverage by increasing portfolio risk. This behavior is consistent with moral hazard: as banks become less capitalized their risk taking incentives increase.

4.5.4. Loan-to-assets regressions

Table 4.5 presents single equation regression results on alternative measures of bank asset risk: the size of banks' loan portfolio and the ratio of non-performing loans to total loans, measuring portfolio quality.

I start with loans to assets in Table 4.5. The baseline OLS regression on long run averages in column (1) shows that CIT is negatively associated with the share of lending in total assets. *CIT* has a long run marginal impact of -0.20, which is significant at the 1% level. Most coefficients have the same signs as those in the corresponding regression on risk weighted assets, which is not surprising given the high correlation between the two variables. There are differences, however. *Basel II* is not significant, and has a positive coefficient now, which is consistent with banks having achieved a reduction in risk weighted assets by lowering risk weights, and not by cutting lending. Another difference is in the coefficient estimates of *Aggregate credit*, yielding a higher estimate in the loan regression, reflecting a closer association between the two variables. The loan-to-assets ratio is negatively related to government indebtedness, which is expected, if there is regulatory/government pressure on banks to absorb government bonds and this crowds out lending. *Capital requirements* also obtains a negative coefficient in column (1) suggesting that banks adjust to higher regulatory capital requirements by buying more low risk assets, such as government bonds, relative to lending.

Returning to the effects of taxes, in column (2) the dynamic model gives a qualitatively similar result to the between regression, with a short run marginal impact of -0.06 and a long run impact of -0.78, albeit both insignificant.

4.5.5. NPL regressions

Columns (3) and (4) of Table 4.5 report results of regressions on portfolio quality. The dependent variable is the log of the share of non-performing loans to total loans. Column (3) presents OLS estimates on the long run averages. *CIT* is estimated to have a long run marginal effect of -5.98, significant at 1%. The dynamic regression in column (4) produces a short run marginal impact of -1.44, significant at 5% and a long run marginal effect of -4.70, significant at 10%. These elasticities are economically quite sizeable. A 10-percentage-point higher *CIT* is expected to be associated with a stock of non-performing loans relative to total assets that is 47-60% lower, which amounts to a difference of 0.28-0.36 standard deviations.

Among the control variables that obtain significant and robust coefficients *ROA* has a negative sign, perhaps because less profitable banks take more risk due to risk shifting. *Market share* has a positive and significant coefficient, which is suggestive of laxer lending standards when loan volume is high. *Fee income* also has a positive and significant coefficient. This could be because more fee income yields better diversified banks, which then allows for increased risk taking. Similarly, *Basel II* picks up a positive coefficient in the OLS regression, suggestive of increased risk taking as made possible by the lower risk weights attained under the Basel II framework. As expected, real GDP growth facilitates debt repayment and improves bank portfolio quality, while a nominal exchange rate depreciation is, on average, expected to increase the share of non-performing loans, which thus seems to dominate the positive effects of larger corporate profits as a result of the depreciation.

4.6. Do taxation and bank regulation interact?

Looking at the results of the previous sections the question arises to what extent the observed pattern, that taxation is positively related with leverage and negatively related with asset risk, is attributable to bank regulation. To gain some insight on this issue, first I test whether the association between taxes, leverage and asset risk varies with regulatory conditions. After this, I look at whether non-financial firms' leverage and asset risk choices are similarly related to CIT as those of banks.

4.6.1. The effect of regulation

In this section I test whether banks react differently to taxation if 1) they hold lower levels of regulatory capital buffers and 2) they are subject to stricter regulatory supervision. My approach is to include the interaction terms *CIT * Buffer dummy* and *CIT * Regulatory stringency* in the baseline regressions on bank leverage and asset risk. The expectation *a priori* is that especially capital abundant banks increase leverage in response to higher tax rates and stricter regulators force banks to reduce asset riskiness if they wish to increase leverage. The former effect is expected, since banks with higher regulatory capital buffer targets have more room to increase leverage without changing their asset allocations while still complying with capital standards. Thus, to the extent that deviating from asset risk targets is costly, I expect these banks to be more responsive.

Table 4.6 shows the results of regressions on bank leverage and RWA with the above mentioned interaction terms included. In column (1) the dependent variable is *Leverage*. Using the between estimator I find a *CIT* coefficient of 0.06 for banks with low excess regulatory capital, which is significant at the 1% level. This is smaller than the baseline estimate in column (1) of Table 4.3. Next, the dummy variable *Buffer dummy* obtains a significant, negative coefficient, reflecting that better capitalized banks have lower leverage. The interaction term is also significant and has a coefficient of 0.23. Thus well-capitalized banks seem to respond more to taxation with an estimated long run impact of 0.29 (= 0.06 + 0.23) on leverage.

The RWA regression shows mirroring results. The CIT coefficient is significantly negative at -0.14, about half the value of the baseline estimate in column (3) of Table 4.3.

Now the capitalization dummy is insignificant, unlike the interaction term, which obtains a negative and significant coefficient of -0.17, bringing the overall effect of CIT for capital abundant banks to -0.32. This evidence is consistent with better capitalized banks having more leeway to increase leverage as a response to higher corporate tax rates and simultaneously reduce asset risk to maintain a targeted regulatory capital buffer. Furthermore, as expected, capital-tight banks seem to reduce asset risk relative to a unit change in leverage more than capital abundant banks: the former adjust leverage and risk at a ratio of 2.33:1 (= 0.14/0.06), while this is 1.10:1 (= 0.32/0.29) for the latter.

Next, in columns (3) and (4) I add the interaction term between *CIT* and *Regulatory stringency*. In the leverage regression (column (3)) *CIT* has a positive and significant coefficient, while the interaction term is negative and also significant. The estimated tax effect for a bank located in a country with average regulatory stringency is 0.08 (=0.24 - 0.03*5.3, see the descriptive statistics in Table 4.1), close to the baseline estimate without interactions (regression 1, Table 4.3). In the RWA regression the standalone CIT variable has a coefficient of 1.133, while the interaction term is negative (-0.27), with both coefficients estimated to be significant. This means that banks located in the least stringent regulatory environments are found to increase RWA in response to taxes, while banks located in countries with a *Regulatory stringency* index larger than 4.18 (=1.13/0.27) reduce asset risk. These results suggest that more stringent regulation reduces banks' incentives (or opportunity) to increase leverage in response to higher taxes.[29] At the same time, banks seem to be forced to cut back on asset risk more aggressively in more stringent regulatory environments, perhaps in order to be able to increase leverage.

Overall, Table 4.6 gives some support to the hypothesis that banks trade off leverage against asset risk because of capital regulation. This conclusion is further reinforced by the results of the next section in which I look at the leverage and asset volatility of non-financial firms.

[29]Nonetheless, for almost all banks the estimated CIT impact on leverage is positive. The marginal impact of *CIT* on leverage is zero when *Regulatory stringency* is equal to 8.44 = 0.27/0.032. There are only five observations with *Regulatory stringency* larger than 8.

4.6.2. Taxation and non-financial firms' leverage and asset risk

A major difference between banks and non-financial firms is that the latter group are not subject to bank regulation and as a result they face fewer constraints on their balance sheets. This suggests that non-financial firms may be able to rely more heavily on debt financing without having to deviate from their optimal project choices. To see if this is the case I look at a sample of non-financial firms and run similar regressions to those in Table 4.3.

The sample includes all publicly listed firms in the Worldscope database, which is the source of firm level balance sheet data. I restrict the sample to the years 1997-2011 to coincide with the sample period of the sample of banks. The dependent variables are *Leverage*, which is defined as total liabilities of total assets; and *Asset volatility*. Asset volatility is obtained using Merton's option pricing model.[30] The firm level control variables are the same as and defined analogously to those in the bank sample, except for certain variables which are not applicable for non-financial firms (*Net interest margin*, *Fee income*, *Wholesale funding*). I include all macro level control variables in the regressions with the exception of bank related variables (*Basel II*, *Activity restrictions*, *Regulatory stringency*, *Capital requirements*, *Market share*, *Aggregate credit*). Summary statistics of the firm level variables in the sample of non-financial firms are shown in Table 4.7. The sample contains 155,099 observations from 16,350 firms in 62 countries.

Table 4.8 presents the results of the regressions on non-financial firms' leverage and asset volatility. As before, I look at long run relationships using the between estimator.[31] In column (1) the dependent variable is *Leverage* and I find that *CIT* obtains a positive and significant coefficient of 0.352. This estimate is about four times as large as that obtained in the OLS regression in column (1) of Table 4.3. Thus, non-financial firms seem to have relatively higher leverage when taxes are higher in comparison to banks. This is consistent with non-financial firms facing fewer (regulatory) constraints to lever

[30] See e.g. Appendix A1 of Anginer et al. (2014) for a description of Merton's method to calculate firms' asset volatility. To estimate equity volatility and the market value of equity I use data from Datastream. I exclude firm-year observations with less than 90 days of nonzero stock returns. The maturity of firms' debt is assumed to be one year. Total debt and the dividend yield is taken from Worldscope. The risk free rate is the yield on the one year US Treasury Bill.

[31] I also ran dynamic panel regressions using GMM in a similar fashion to the regressions in Table 4.3. In the leverage regression *CIT* obtains a negative, but insignificant coefficient. In the *Asset volatility* regression *CIT* obtains a positive and significant coefficient. These results are not reported because the regressions fail the basic diagnostic tests required for unbiased estimation.

up. This result is robust to the inclusion of industry dummies as seen in column (2): the estimated coefficient of *CIT* is now 0.357. The industry dummies indicate that a firm belongs to a certain industry according to the three-digit SIC classification system. Frank and Goyal (2009) show that median industry leverage is a core predictor of firm leverage and provide several possible explanations (such as peer effects and industry heterogeneity in the types of assets, business risk, technology, or regulation). The industry dummies capture these factors.

Next, turning to the asset risk regressions, I find that *CIT* is positively related to asset volatility as evidenced by the positive and significant coefficient (at 0.0155) in column (3). When I add industry dummies in regression (4) the estimate changes slightly to 0.0146 but remains significant. Thus, for non-financial firms it appears that there is a positive relationship between corporate income tax rates and asset risk, while for banks this relationship is negative. The finding of riskier firms in high-tax countries is consistent with moral hazard: firms choosing more risky projects when their profitability is weakened by higher taxes. Furthermore, it also suggests that an alternative explanation for the observed negative relationship between bank asset risk and tax rates is not likely. According to this explanation banks lend to less risky borrowers because taxation is asymmetric: the government shares from the profits but not from losses, thereby reducing risk taking incentives.

4.7. Taxes and overall bank risk

In this section I assess how CIT impacts overall bank stability. I regress *Z-score* on *CIT* and the same control variables as before except that I exclude *ROA* as it is directly related to *Z-score*. Table 4.9 reports the results. In column (1) using the between estimator, I find a significantly positive coefficient estimate of 0.87, which is about the same as the standard deviation of the log of banks' Z-score. Thus, a 10% pp tax increase is associated with an increase of about one tenth of the standard deviation of *Z-score* – a modest change by any account. This suggests that the portfolio risk reduction more than offsets the risk increasing effect of leverage. Since regulation alone does not justify a full, or more than full offset, it seems likely that taxation has an effect on bank risk through other channels as well. One possibility is that taxation reduces the benefit of risk taking because the government shares in a bank's profits, but not in the losses.The GMM regression in column (2) gives further evidence that the quantitative impact of taxation on banks' Z-score is small, as the coefficient estimates are statistically insignificant, but one has to be cautious, since the lagged dependent variable obtains a coefficient close to one, which makes measurement imprecise (Blundell and Bond, 1998).

4.8. Discussion and conclusions

In the previous sections I established that in countries where corporate income tax rates are higher banks have higher leverage and less risky assets, irrespective of whether risk is measured as the average regulatory risk weight, loan to assets ratio or as the share of non-performing loans. This pattern is consistent with the following story: since taxation drives a wedge between the cost of debt and equity financing banks' optimal capital structure favors debt financing in countries where tax rates are higher; however, in order to mitigate the likelihood of regulatory noncompliance they reduce the riskiness of their assets.

I also present evidence that suggests that there is a trade-off between leverage and asset risk which appears to be driven by bank specific factors, and especially bank regulation. Firstly, well capitalized banks have relatively higher leverage ratios in countries with higher tax rates than banks that are more close to the regulatory constraint. At the same time, these banks have relatively less risky assets, presumably to maintain the level of regulatory compliance. Secondly, the association between tax rates and leverage is weaker in countries where regulation is stricter, while in these countries the negative association between asset risk and tax rates is stronger.

The explanation that banks reduce asset risk when CIT rates are higher as a result of regulatory pressure is reinforced by the results from the sample of non-financial firms. In particular, I find that the positive relationship between tax rates and leverage for these firms is larger than for banks. Additionally, the relationship between asset volatility and tax rates is positive for the sample of non-financial firms, as opposed to the negative association for banks, probably because these firms do not face an asset-risk dependent capital constraint and may take more risk as a result of eroded profits.

While attention in existing literature has mostly focused on the leverage incentivizing effect of corporate income taxation, the results in this paper imply that the portfolio reallocation effects are at least as important. Furthermore, the measured effect of corporate income taxes on overall bank risk seems to be modest. These results have implications for recently implemented and potential future policy measures. Firstly, they suggest that the elimination of interest deductibility of debt will not make banks safer to the extent that one might have hoped for. In this regard banks are different from non-financial companies. Secondly, after the crisis several European countries implemented laws that require banks to pay levies after their liabilities. In some cases the explicit purpose of the levies is to discourage banks from relying excessively on (short term) debt financing and thus reduce funding risk. Like CIT, these levies create a wedge between the cost of debt and equity financing, albeit with an opposite sign. This suggests that the regulatory induced trade-off between leverage and asset risk will encourage banks to choose riskier assets after the introduction of the levies. Devereux et al. (2013) present evidence that this has already occurred in countries that introduced the new duties. Thus, it is unclear whether the levies will make banks overall safer.

The observation that the estimated tax elasticity of debt for banks is smaller than that of non-financial firms also suggests that the primary driver for banks' debt bias is not corporate income taxation, but rather other factors, such as access to the financial safety net. An approach that seems more effective at reducing banks' debt-bias thus involves the improvement of the resolution regime and the reduction of implicit subsidies to bank risk taking.

Finally, the relative size of welfare costs associated with the taxation of banks as compared to that of non-financial firms is not clear. In both cases higher leverage leads to higher expected costs of bankruptcy. In case of banks, these can be mitigated if they take less risk in the form of less risky lending because of bank regulation (and if capital requirements do not fully eliminate inefficient lending in the absence taxation). However, the converse might also be true: the interaction of taxation and regulation may lead to an inefficiently low level of lending with adverse effects for the real economy, if firms cannot switch to other forms of financing.

4.9. Appendix

Table 4.A1: Variable definitions and source of data

Variable	Definition	Source
CIT	Top statutory corporate income tax rate.	OECD, KPMG Corporate and Indirect Tax Surveys 2007, 2010 and 2011
CIT dummy	1 if CIT is higher than the average CIT rate in the sample, which is 27.31% and 0 otherwise.	OECD; KPMG Corporate and Indirect Tax Surveys 2007, 2010 and 2011
Leverage	Total liabilities over total assets.	Bankscope, Worldscope
RWA	Risk-weighted assets over total assets.	Bankscope
Loans	Total loans to total assets.	Bankscope
NPL	Natural logarithm of non-performing loans to total loans.	Bankscope
Buffer dummy	1 if a bank has a regulatory capital buffer on average more than the median, which is 0.074 and 0 otherwise. Regulatory capital buffer is Tier I + Tier 2 capital over risk-weighted assets minus capital requirements.	Bankscope and (Barth et al., 2001), (Barth et al., 2004), Barth et al. (2008)
Z-score	Natural logarithm of Z-score = (Total equity/Total assets + ROA) / standard deviation of ROA. The standard deviation of ROA is calculated over the whole sample period.	Bankscope
Size	Natural logarithm of the book value of total assets.	Bankscope, Worldscope
$Size^2$	The square of the natural logarithm of the book value of total assets.	Bankscope, Worldscope
Net interest margin	Interest income minus interest expenses over interest-bearing (total earning) assets.	Bankscope
ROA	Return over average assets.	Bankscope, Worldscope
Fee income	Non-interest income over total operating income.	Bankscope
Wholesale funding	Non-deposit funding over total deposits and short term funding.	Bankscope
Non-interest expenses	Non-interest expenses over total assets.	Bankscope, Worldscope

Asset volatility	Calculations based on Merton's option pricing model. See e.g. Appendix A1 of (Anginer et al., 2014).	Worldscope, Datastream
No ownership data dummy	1 if there is no ownership information available, zero otherwise.	(Claessens and van Horen, 2014)
CIT diff (Local - owner)	Top statutory CIT rate in the country of the bank's location minus the top statutory CIT rate applicable in the country where its owner is headquartered. Zero if no data is available.	(Claessens and van Horen, 2014)
CIT diff (Local - frgn subsidiary)	Top statutory CIT rate in the country where the bank is headquartered minus the (unweighted) average of the top statutory CIT rates applicable in the countries where its foreign subsidiaries are located. A Parent-subsidiary relationship is established if the parent has an ultimate ownership larger than 50% in the subsidiary. Zero if no data is available.	Bankscope
Market share	Total assets relative to the sum of all other banks' assets in the country of residence.	Bankscope
Aggregate credit	Sum of all other banks' loans relative to all banks' assets in the country of residence.	Bankscope
Basel II	1 if the Basel II rules were effective in the country of residence and 0 otherwise.	BIS progress reports on the implementation of the Basel regulatory framework
RGDP growth	Annual percentage change of constant price GDP.	World Economic Outlook database
CPI	Inflation, annual end of period consumer price change.	World Economic Outlook database
Gvt Debt/GDP	General government gross debt to GDP.	World Economic Outlook database
GDP per capita	GDP per capita on a US dollar PPP basis.	World Economic Outlook database
Exchange rate chg	Annual percentage point changes in the nominal exhange rate.	World Economic Outlook database
Activity restrictions	Index of regulatory restrictions of certain activities.	(Barth et al., 2001), (Barth et al., 2004), Barth et al. (2008), (Čihák et al., 2012)

Regulatory stringency	Index of regulatory stringency of capital calculation rules.	(Barth et al., 2001), (Barth et al., 2004), Barth et al. (2008), (Čihák et al., 2012)
Capital requirements	Minimum capital adequacy requirement expressed as a percentage of Tier I + Tier 2 capital over risk-weighted assets.	(Barth et al., 2001), (Barth et al., 2004), Barth et al. (2008), (Čihák et al., 2012)
Creditor rights	An index of statutory rights of creditors.	Djankov et al. (2007)

4.9.1. Partial adjustment model

The partial adjustment model (equation (4.4)) used in this paper is standard in the bank capital structure literature. It builds on Shrieves and Dahl (1992), who assume that observed changes in capital and risk have two components, discretionary adjustment and exogenous shocks. Discretionary changes are the result of banks' optimal capital and risk decisions, while exogenous shocks to risk might reflect unexpected changes in the business cycles or in case of capital, unexpected loan losses. Denoting y_{ijt} either leverage or asset risk, this assumption can be formulated as

$$\Delta y_{ijt} = \Delta y^b_{ijt} + u_{ijt} \tag{4.7}$$

The econometrician observes Δy_{ijt}, the change of leverage/asset risk of bank i in country j in year t. However, banks' planned leverage and risk adjustment Δy^b_{ijt}, and the exogenous shocks u_{ijt} and v_{ijt} are unobservable. Shrieves and Dahl (1992) and the subsequent literature assume that banks have target leverage and risk levels (y^*). The final assumption of the model is that banks do not immediately adjust to their target levels after either leverage and/or risk was hit by a shock in the previous period. Instead, it is assumed that the speed of adjustment is proportional to the distance from the target level:

$$\Delta y^b_{ijt} = \psi(y^*_{ijt} - y_{ijt-1}) \tag{4.8}$$

Inserting the equation for banks' planned adjustment (equation (4.8)) into the observed adjustment equation (4.7) and assuming that the target levels (y^*) are a linear function of some determinants yields equation (4.4) after some rewriting.

4.10. Tables

Table 4.1: Descriptive statistics – Sample of banks

See Table 4.A1 for variable definitions.

	No. of obs.	Mean	St. D.	Minimum	Maximum
CIT	148608	0.382	0.0533	0.100	0.560
CIT dummy	148608	0.956	0.206	0	1
Leverage	148608	0.893	0.0678	0.214	0.979
RWA	106688	0.676	0.138	0.238	1.000
Loans	148608	0.632	0.168	0.0659	0.936
NPL	103624	-4.850	1.660	-9.488	-1.465
Z-score	147782	3.219	0.975	.459	5.544
Buffer dummy	127525	0.472	0.499	0	1
Size	148608	12.14	1.470	8.809	16.63
Size^2	148608	149.7	38.33	17.68	454.4
Net interest margin	148608	0.0385	0.0150	0.00500	0.134
ROA	148608	0.00707	0.0121	-0.0530	0.0645
Fee income	148608	0.190	0.151	-0.146	0.968
Wholesale funding	148608	0.0793	0.152	0	0.950
Non-interest expenses	148608	0.0323	0.0339	0.00491	0.453
No ownership data dummy	148608	0.945	0.2285654	0.000	1.000
CIT diff (Local - owner)	148608	-0.000564	0.0115	-0.410	0.300
CIT diff (Local - frgn subsidiary)	148608	0.000291	0.0114	-0.338	0.350
Market share	148608	0.00397	0.0329	3.44e-08	1
Aggregate credit	148608	0.605	0.0612	0	1.060
Basel II	148608	0.202	0.402	0	1
RGDP growth	148608	0.0204	0.0227	-0.177	0.164
CPI	148608	0.0253	0.0204	-0.0638	1.087
Gvt Debt/GDP	148608	0.706	0.227	0.0389	1.864
GDP per capita	148608	10.47	0.411	6.567	10.89
Exchange rate chg	148608	0.000119	0.0577	-0.188	2.198
Activity restrictions	148608	10.79	2.104	4	16
Regulatory stringency	148608	5.343	0.671	2	9
Capital requirements	148608	0.0808	0.00487	0.0600	0.190
Creditor rights	148608	1.338	0.738	0	4

Table 4.2: Correlation matrix of main variables

CIT is the top statutory corporate income tax rate. Leverage is total liabilities over total assets. RWA is risk-weighted assets over total assets. Loans is total loans to total assets. NPL is the natural logarithm of non-performing loans to total loans.

	CIT	Leverage	RWA	Loans	NPL
CIT	1				
Leverage	0.165***	1			
RWA	-0.00755*	0.124***	1		
Loans	-0.0371***	0.220***	0.748***	1	
NPL	-0.200***	-0.0234***	0.0505***	-0.0230***	1

Table 4.3: Single equation leverage and RWA regressions

The dependent variable is *Leverage* in columns (1) and (2) and risk-weighted assets to total assets *(RWA)* in columns (3) and (4). Columns (1) and (3) are estimated with OLS on the between-transformed variables. Columns (2) and (4) are estimated with the system GMM estimator, where only the lagged dependent variables are treated as endogenous and both regressions include bank and time effects. In column (2) only the second lag, in column (4) only the third lag is used to instrument the lagged dependent variable. The sample in regression (4) excludes the years prior to 2004. The two-step estimator with the (Windmeijer, 2005) correction is applied. In columns (2) and (4) *CIT (Long run)* is the long run marginal effect of *CIT* calculated as $\gamma/(1-\beta)$ in equation (4.4). The standard errors of the long run marginal effect of CIT are calculated using the delta method and are clustered at the country level. t statistics in parentheses. See Table 4.A1 for variable definitions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

	Leverage		RWA	
	(1)	(2)	(3)	(4)
	Between	GMM	Between	GMM
Lagged value		0.576***		0.843***
		(6.63)		(94.04)
CIT	0.0913***	0.0473***	-0.198***	-0.109**
	(7.60)	(2.76)	(-2.80)	(-2.21)
Size	0.0315***	0.0105***	0.0582***	0.00545***
	(13.58)	(4.27)	(11.71)	(3.98)
Size^2	-0.000679***	-0.000272***	-0.00137***	-0.000145*
	(-7.70)	(-2.79)	(-7.23)	(-1.89)
Net interest margin	-0.716***	0.261***	4.436***	0.564***
	(-16.08)	(3.11)	(36.17)	(3.51)
ROA	-0.0116	-0.947***	-2.746***	-0.206***
	(-0.22)	(-23.09)	(-21.73)	(-2.90)
Fee income	-0.0343***	0.0105	-0.0685***	-0.0303***
	(-7.57)	(1.33)	(-5.40)	(-5.85)
Wholesale funding	-0.0692***	-0.00561	0.0712***	0.0175
	(-18.98)	(-1.44)	(5.38)	(0.94)
Non-interest expenses	-0.341***	-0.355***	-0.0862	0.212***
	(-17.12)	(-8.22)	(-1.31)	(6.43)
Market share	0.0673***	0.0312*	-0.0307	0.0331*
	(5.26)	(1.81)	(-0.72)	(1.71)
Aggregate credit	0.0783***	0.0131	0.207***	0.0585***
	(8.30)	(1.06)	(6.71)	(3.05)
Basel II	-0.0596***	-0.00302	-0.149***	-0.0169***
	(-19.63)	(-1.59)	(-20.95)	(-3.35)
RGDP growth	-0.358***	0.0811***	-1.398***	-0.0435
	(-6.35)	(3.09)	(-7.01)	(-0.31)
CPI	0.0218	-0.0213	0.596***	0.0874
	(0.58)	(-0.88)	(3.99)	(0.63)
Gvt Debt/GDP	-0.0220***	0.000977	0.0873***	0.0168**
	(-7.41)	(0.18)	(6.35)	(2.47)
GDP per capita	0.00181	0.00232	0.0397***	0.00327
	(1.03)	(0.96)	(6.43)	(0.71)
Exchange rate chg	-0.0225	-0.0224***	-0.783***	-0.107*
	(-1.04)	(-5.75)	(-6.45)	(-1.72)
Activity restrictions	-0.00425***	-0.000895	0.00628***	0.00121
	(-10.51)	(-1.42)	(3.93)	(0.77)

Regulatory stringency	-0.000376	0.000674	-0.00932***	0.000599
	(-0.45)	(0.63)	(-3.03)	(0.31)
Capital requirements	-0.269**	-0.359	0.150	-0.0466
	(-2.16)	(-1.62)	(0.42)	(-0.14)
Creditor rights	0.00312***	0.000825	0.0233***	-0.00452
	(3.53)	(0.45)	(4.23)	(-1.04)
Constant	0.659***	0.280***	-0.514***	-0.00273
	(21.08)	(3.78)	(-5.36)	(-0.03)
Observations	148608	129378	106688	62806
Adjusted R^2	0.354		0.212	
Number of instruments		57		45
AR(1) test p value		0.000		0.000
AR(2) test p value		0.219		0.00503
AR(3) test p value				0.908
Hansen test p value		0.448		0.911
CIT (Long run)		0.112**		-0.696*
		(2.88)		(-2.23)

Table 4.4: Robustness checks

The dependent variable is *Leverage* in columns (1), (3) and (5), the first difference of *Leverage* in column (7); risk-weighted assets to total assets *(RWA)* in columns (2), (4) and (6) and the first difference of *(RWA)* in column (8). Columns (1)-(6) are estimated with OLS on the between-transformed variables. Columns (7)-(8) are estimated as a system of simultaneous equations using 3SLS and include time effects. *L.Leverage* (*L.RWA*) is the first lag of *Leverage* (*RWA*) and *D.Leverage* (*D.RWA*) is the first lag of *Leverage* (*RWA*). *CIT (Long run)* is the long run marginal effect of *CIT* calculated as $-b_1/a_1$ and $-b_2/a_2$ in equations (4.5) and (4.6) for *Leverage* and *RWA*, respectively. The standard error of the long run tax impact is calculated with the delta method. t statistics in parentheses. See Table 4.A1 for variable definitions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

	Pre-crisis sample		Without US banks		Ownership structure		SUR	
	(1) Leverage	(2) RWA	(3) Leverage	(4) RWA	(5) Leverage	(6) RWA	(7) D.Leverage	(8) D.RWA
CIT	0.159***	-0.526***	0.111***	-0.0834	0.0777***	-0.196***	0.0268***	-0.0994***
	(12.42)	(-3.62)	(6.36)	(-0.65)	(6.27)	(-2.63)	(3.06)	(-4.92)
L.Leverage							-0.386***	
							(-209.97)	
L.RWA								-0.130***
								(-83.97)
D.Leverage								0.356***
								(36.28)
D.RWA							-0.0924***	
							(-17.17)	
CIT diff (Local - frgn subsidiary)					-0.00582	-0.0543		
					(-0.14)	(-0.39)		
CIT diff (Local - owner)					-0.0120	0.0847		
					(-0.32)	(0.56)		
No ownership data dummy					0.0160***	-0.0212*		
					(6.30)	(-1.86)		
Size	0.0439***	0.0344***	0.0447***	0.104***	0.0303***	0.0607***	0.00796***	0.00739***

	(15.90)	(5.89)	(9.89)	(6.09)	(12.97)	(11.70)	(21.14)	(8.52)
$Size^2$	-0.00122***	-0.000367	-0.000971***	-0.00350***	-0.000619***	-0.00148***	-0.000269***	-0.000195***
	(-11.45)	(-1.61)	(-5.73)	(-5.99)	(-6.94)	(-7.40)	(-18.51)	(-5.86)
Net interest margin	0.429***	5.632***	-1.241***	1.610***	-0.701***	4.435***	0.347***	0.515***
	(7.85)	(40.22)	(-17.59)	(4.91)	(-15.76)	(36.15)	(37.74)	(22.66)
ROA	0.607***	-2.220***	-0.700***	0.554	-0.0307	-2.739***	-1.045***	-0.0188
	(10.28)	(-15.64)	(-7.77)	(1.41)	(-0.59)	(-21.67)	(-118.10)	(-0.81)
Fee income	0.0342***	-0.0538***	-0.0780***	-0.0462	-0.0334***	-0.0690***	0.0211***	-0.0241***
	(6.45)	(-3.55)	(-10.78)	(-1.23)	(-7.36)	(-5.43)	(23.14)	(-11.46)
Wholesale funding	-0.0622***	0.0653***	-0.0682***	0.0347	-0.0695***	0.0715***	0.00491***	0.0136***
	(-14.56)	(4.12)	(-13.64)	(1.36)	(-19.01)	(5.38)	(4.34)	(5.21)
Non-interest expenses	-1.080***	-0.277***	-0.0984***	0.656***	-0.351***	-0.0834	-0.317***	0.0803***
	(-35.62)	(-3.79)	(-3.46)	(3.58)	(-17.57)	(-1.26)	(-58.09)	(6.50)
Market share	0.0427***	0.125	0.0520***	-0.0568	0.0722***	-0.0374	0.0317***	0.0484***
	(2.94)	(1.60)	(3.19)	(-0.98)	(5.62)	(-0.88)	(5.92)	(3.93)
Aggregate credit	-0.000366	0.212**	0.0806***	0.0684	0.0790***	0.206***	0.0284***	0.0587***
	(-0.03)	(1.98)	(6.32)	(1.41)	(8.37)	(6.64)	(6.27)	(5.64)
Basel II			-0.0471***	-0.0391**	-0.0591***	-0.150***	-0.00552***	-0.0187***
			(-10.24)	(-2.42)	(-19.43)	(-20.97)	(-5.08)	(-7.48)
RGDP growth	-0.363***	-1.817***	-0.342***	-0.753**	-0.343***	-1.341***	0.165***	0.0701
	(-4.95)	(-4.03)	(-4.63)	(-2.28)	(-6.10)	(-6.61)	(6.41)	(1.18)
CPI	-0.313***	2.565***	0.0980**	0.361*	0.00842	0.587***	0.0421***	0.0226
	(-7.04)	(4.06)	(1.99)	(1.70)	(0.22)	(3.93)	(3.33)	(0.77)
Gvt Debt/GDP	-0.00679*	0.195***	-0.0313***	0.0901***	-0.0237***	0.0938***	0.00187	0.0179***
	(-1.87)	(6.27)	(-6.71)	(4.10)	(-7.95)	(6.57)	(1.07)	(4.47)
GDP per capita	-0.0175***	0.0835***	0.000230	0.0249**	-0.00215	0.0419***	0.00409***	0.00382*

	(-8.56)	(4.81)	(0.08)	(2.48)	(-1.15)	(6.57)	(4.62)	(1.88)
Exchange rate chg	-0.0464**	0.671**	-0.0253	-0.623***	-0.0172	-0.780***	0.00154	-0.0719***
	(-2.06)	(2.10)	(-0.92)	(-3.65)	(-0.80)	(-6.41)	(0.19)	(-3.89)
Activity restrictions	-0.00446***	-0.0254***	-0.00407***	0.00798***	-0.00421***	0.00647***	-0.000656***	0.000350
	(-8.37)	(-4.84)	(-5.38)	(2.79)	(-10.40)	(4.02)	(-3.06)	(0.71)
Regulatory stringency	0.00443***	-0.0395***	-0.000905	0.00269	-0.000491	-0.00977***	-0.00251***	0.00133
	(4.56)	(-5.42)	(-0.84)	(0.65)	(-0.58)	(-3.15)	(-5.41)	(1.25)
Capital requirements	-2.045***	-0.0598	0.181	1.386***	-0.305**	0.139	-0.227***	-0.414***
	(-12.51)	(-0.06)	(1.12)	(2.70)	(-2.45)	(0.38)	(-4.23)	(-3.35)
Creditor rights	0.00125	-0.0275***	0.00342***	0.00132	0.00286***	0.0231***	-0.000136	-0.00476***
	(1.24)	(-2.80)	(2.70)	(0.17)	(3.24)	(4.13)	(-0.19)	(-2.86)
Constant	0.880***	-0.299	0.534***	-0.684***	0.700***	-0.536***		
	(22.98)	(-1.24)	(10.04)	(-3.52)	(21.94)	(-5.52)		
Observations	98563	65053	39641	5268	148608	106688	95259	95259
Adjusted R^2	0.317	0.212	0.450	0.185	0.356	0.212		
CIT (Long run)							0.0695**	-0.763***
							(3.06)	(-4.92)

Table 4.5: Single equation regressions on alternative portfolio risk measures

The dependent variable is total loans to total assets (*Loans*) in columns (1)-(2) and log-share of non-performing loans to total loans (*NPL*) in columns (3)-(4). Columns (1) and (3) are estimated with OLS on the between-transformed variables. Columns (2) and (4) are estimated with the system GMM estimator, where only the lagged dependent variables are treated as endogenous and both regressions include bank and time effects. In column (2) only the second lag, in column (4) only the third lag is used to instrument the lagged dependent variable. The two-step estimator with the (Windmeijer, 2005) correction is applied. In columns (2) and (4) *CIT (Long run)* is the long run marginal effect of *CIT* calculated as $\gamma/(1-\beta)$ in equation (4.4). The standard errors of the long run marginal effect of CIT are calculated using the delta method and are clustered at the country level. t statistics in parentheses. See Table 4.A1 for variable definitions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

	Loans		NPL	
	(1) Between	(2) GMM	(3) Between	(4) GMM
Lagged value		0.920***		0.693***
		(87.53)		(38.82)
CIT	-0.199***	-0.0618	-5.978***	-1.442**
	(-7.36)	(-1.64)	(-15.00)	(-2.36)
Size	0.0837***	-0.00149	-0.00253	0.0691***
	(16.00)	(-0.86)	(-0.06)	(3.56)
Size^2	-0.00231***	0.0000265	0.00141	-0.00163**
	(-11.61)	(0.48)	(0.92)	(-1.99)
Net interest margin	2.855***	0.509***	12.53***	3.752***
	(28.44)	(3.24)	(15.75)	(7.62)
ROA	-2.031***	-0.538***	-30.74***	-13.11***
	(-17.16)	(-4.41)	(-32.06)	(-8.11)
Fee income	-0.248***	-0.0132*	0.446***	0.224***
	(-24.29)	(-1.94)	(5.17)	(3.57)
Wholesale funding	0.0458***	0.0139	0.275***	0.0879
	(5.57)	(1.17)	(3.51)	(0.87)
Non-interest expenses	-0.0602	0.0310	-0.995***	0.0848
	(-1.34)	(1.13)	(-2.81)	(0.25)
Market share	0.268***	0.0414**	1.010***	0.465*
	(9.31)	(2.19)	(4.19)	(1.68)
Aggregate credit	0.685***	0.0900***	0.634***	0.0180
	(32.19)	(4.49)	(3.27)	(0.06)
Basel II	0.00602	-0.0148***	0.177***	-0.0305
	(0.88)	(-2.79)	(3.80)	(-0.80)
RGDP growth	-0.256**	0.0884	-5.991***	-4.414***
	(-2.01)	(1.12)	(-6.49)	(-3.51)
CPI	-0.305***	-0.0399	-1.939***	0.0332
	(-3.57)	(-0.41)	(-2.62)	(0.08)
Gvt Debt/GDP	-0.0802***	0.000851	2.429***	0.722***
	(-12.00)	(0.08)	(45.00)	(12.50)
GDP per capita	0.0282***	0.00399	-0.857***	-0.207***
	(7.14)	(0.66)	(-26.41)	(-4.61)
Exchange rate chg	-0.0771	-0.0326	-1.350***	-0.608***
	(-1.59)	(-1.47)	(-4.28)	(-4.87)
Activity restrictions	-0.00606***	-0.00220***	-0.00121	0.0330**
	(-6.64)	(-3.08)	(-0.12)	(2.42)
Regulatory stringency	0.00219	-0.00114	-0.0226	-0.00542

	(1.15)	(-0.46)	(-1.30)	(-0.19)
Capital requirements	-1.408***	-0.378*	12.61***	2.253
	(-5.02)	(-1.68)	(5.56)	(0.45)
Creditor rights	-0.0118***	-0.00272	-0.00578	-0.0587
	(-5.95)	(-1.42)	(-0.25)	(-1.27)
Constant	-0.470***	0.0377	2.951***	-0.327
	(-6.67)	(0.50)	(5.38)	(-0.40)
Observations	148608	129378	103624	84882
Adjusted R^2	0.233		0.430	
Number of instruments		57		55
AR(1) test p value		0.000		0.000
AR(2) test p value		0.943		0.000
AR(3) test p value				0.526
Hansen test p value		0.342		0.145
CIT (Long run)		-0.777		-4.697*
		(-1.63)		(-2.33)

Table 4.6: Effect of regulation

The dependent variables are *Leverage* in columns (1) and (3) and risk-weighted assets over total assets (*RWA*) in columns (2) and (4). All regressions are estimated with OLS on the between-transformed variables. t statistics in parentheses. See Table 4.A1 for variable definitions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

	Capital tightness		Regulatory stringency	
	(1) Leverage	(2) RWA	(3) Leverage	(4) RWA
CIT	0.0619***	-0.137**	0.268***	1.331***
	(3.56)	(-1.99)	(4.06)	(4.84)
CIT * Buffer dummy	0.230***	-0.174***		
	(11.42)	(-3.00)		
CIT * Regulatory stringency			-0.0316***	-0.273***
			(-2.72)	(-5.75)
Buffer dummy	-0.132***	-0.0262		
	(-17.28)	(-1.18)		
Size	0.0106***	0.0375***	0.0315***	0.0574***
	(5.50)	(8.11)	(13.61)	(11.57)
$Size^2$	-0.000278***	-0.000971***	-0.000680***	-0.00132***
	(-3.83)	(-5.52)	(-7.70)	(-6.97)
Net interest margin	-0.0976**	4.007***	-0.709***	4.398***
	(-2.22)	(34.81)	(-15.90)	(35.86)
ROA	0.101**	-2.635***	-0.0152	-2.703***
	(2.11)	(-22.45)	(-0.29)	(-21.38)
Fee income	0.0328***	-0.103***	-0.0338***	-0.0702***
	(7.27)	(-8.67)	(-7.45)	(-5.54)
Wholesale funding	-0.0376***	0.0850***	-0.0696***	0.0703***
	(-9.22)	(6.87)	(-19.08)	(5.32)
Non-interest expenses	-0.760***	0.132**	-0.346***	-0.0923
	(-31.91)	(2.15)	(-17.30)	(-1.40)
Market share	0.0734***	-0.0493	0.0692***	-0.00587
	(6.30)	(-1.25)	(5.40)	(-0.14)
Aggregate credit	0.0744***	0.146***	0.0776***	0.242***
	(7.85)	(4.99)	(8.22)	(7.70)
Basel II	-0.0267***	-0.114***	-0.0601***	-0.147***
	(-9.32)	(-16.91)	(-19.77)	(-20.63)
RGDP growth	0.0297	-1.504***	-0.364***	-1.430***
	(0.48)	(-8.01)	(-6.45)	(-7.17)
CPI	0.00112	0.701***	0.0257	0.661***
	(0.03)	(5.07)	(0.68)	(4.42)
Gvt Debt/GDP	0.00600**	0.0761***	-0.0218***	0.0718***
	(2.08)	(5.88)	(-7.34)	(5.14)
GDP per capita	-0.00256	0.0361***	0.000707	0.0327***
	(-1.46)	(6.21)	(0.39)	(5.20)
Exchange rate chg	-0.00663	-0.829***	-0.0320	-0.824***
	(-0.24)	(-7.32)	(-1.47)	(-6.78)
Activity restrictions	-0.00257***	0.00804***	-0.00434***	0.00408**
	(-5.75)	(5.25)	(-10.68)	(2.48)
Regulatory stringency	-0.000458	-0.00699**	0.00867**	0.0598***
	(-0.55)	(-2.43)	(2.53)	(4.82)

Capital requirements	-0.769***	0.222	-0.341***	-0.289
	(-6.51)	(0.66)	(-2.68)	(-0.79)
Creditor rights	0.00676***	0.0214***	0.00360***	0.0260***
	(6.39)	(4.11)	(4.00)	(4.70)
Constant	0.890***	-0.250***	0.624***	-0.792***
	(29.27)	(-2.76)	(18.54)	(-7.38)
Observations	127525	106606	148608	106688
Adjusted R^2	0.406	0.325	0.355	0.215

Table 4.7: Descriptive statistics – Sample of non-financial firms

The table shows descriptive statistics for the sample of non-financial firms and corresponds to regressions in Table 4.8. CIT is the top statutory corporate income tax rate. Leverage is total liabilities over total assets. Asset volatility is the volatility of a firms' assets based based on Merton's option pricing model. Size is the natural logarithm of the book value of total assets. Size^2 is the square of the natural logarithm of the book value of total assets. Net interest margin is interest income minus interest expenses over interest-bearing (total earning) assets. ROA is before-tax income over average assets. Non-interest expenses is non-interest expenses over total assets. GDP per capita is the natural log of GDP per capita on a US dollar PPP basis. RGDP growth is the annual percentage change of constant price GDP. Gvt Debt/GDP is general government gross debt to GDP. CPI is the annual end of period consumer price change. Exchange rate chg is the annual percentage point changes in the nominal exhange rate. Creditor rights is an index of statutory rights of creditors.

	No. of obs.	Mean	St. D.	Minimum	Maximum
CIT	155099	0.337	0.0706	0.100	0.568
Leverage	155099	0.500	0.220	0.0534	0.930
Asset volatility	155099	0.0248	0.0174	0.00432	0.0879
Size	155099	12.41	1.934	6.864	16.58
Size^2	155099	157.8	48.40	47.11	275.0
ROA	155099	0.00877	0.217	-1.461	0.314
Non-interest expenses	155099	0.972	0.0445	0.755	1
GDP per capita	155099	9.950	0.890	7.164	11.02
RGDP growth	155099	0.0334	0.0328	-0.148	0.148
Gvt Debt/GDP	155099	0.735	0.481	0.0389	2.366
Inflation	155099	0.0298	0.0345	-0.0355	0.685
Exchange rate chg	155099	-0.0000317	0.0773	-0.281	2.198
Creditor rights	155099	1.826	1.227	-1	5

Table 4.8: Non-financial firms' leverage and asset risk

The dependent variables are *Leverage* in columns (1) and (2) and *Asset volatility* in columns (3) and (4). All regressions are estimated with OLS on the between-transformed variables. Industry effects account for three-digit SIC sector-specific factors in columns (2) and (4). t statistics in parentheses. See Table 4.A1 for variable definitions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

	Leverage		Asset volatility	
	(1)	(2)	(3)	(4)
CIT	0.352***	0.357***	0.0155***	0.0146***
	(16.05)	(16.97)	(11.29)	(11.04)
Size	-0.00965	-0.0224***	-0.0185***	-0.0173***
	(-1.53)	(-3.68)	(-46.74)	(-45.20)
Size^2	0.00155***	0.00190***	0.000595***	0.000555***
	(6.13)	(7.74)	(37.39)	(35.96)
ROA	-0.0789***	-0.0997***	-0.0212***	-0.0195***
	(-12.56)	(-16.44)	(-53.74)	(-51.12)
Non-interest expenses	-1.293***	-1.475***	0.0481***	0.0484***
	(-43.82)	(-48.33)	(25.99)	(25.21)
GDP per capita	-0.0316***	-0.0216***	0.00590***	0.00512***
	(-12.51)	(-8.81)	(37.27)	(33.18)
RGDP growth	-0.0722	-0.290***	0.0547***	0.0640***
	(-0.89)	(-3.74)	(10.77)	(13.12)
Gvt Debt/GDP	0.0481***	0.0267***	-0.00548***	-0.00425***
	(12.21)	(7.03)	(-22.18)	(-17.80)
Inflation	-0.370***	-0.275***	0.0424***	0.0405***
	(-5.59)	(-4.31)	(10.22)	(10.10)
Exchange rate chg	0.470***	0.307***	-0.0151***	-0.00579***
	(14.25)	(9.73)	(-7.32)	(-2.91)
Creditor rights	0.00818***	0.00392***	-0.00103***	-0.000820***
	(7.63)	(3.82)	(-15.33)	(-12.68)
Constant	1.796***	1.859***	0.0534***	0.0597***
	(30.77)	(30.14)	(14.58)	(15.37)
Observations	155099	155099	155099	155099
Adjusted R^2	0.188	0.279	0.569	0.615
Industry effects	No	Yes	No	Yes

Table 4.9: Overall bank risk – Z-score regressions

The dependent variable in columns (1) and (2) is the natural logarithm of Z-score *(Z-score)*. Columns (1) is estimated with OLS on the between-transformed variables. Regression (2) is estimated with the system GMM estimator with only the lagged dependent variable treated as endogenous, instrumented only by the third lag. Column (2) includes bank and time effects as well. The two-step estimator with the (Windmeijer, 2005) correction is applied. In column (2) *CIT (Long run)* is the long run marginal effect of *CIT* calculated as $\gamma/(1-\beta)$ in equation (4.4). The standard errors of the long run marginal effect of CIT are calculated using the delta method and are clustered at the country level. t statistics in parentheses. See Table 4.A1 for variable definitions. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

	Z-score	
	(1) Between	(2) GMM
Lagged value		0.979***
		(173.94)
CIT	0.871***	0.0861
	(4.72)	(1.14)
Size	-0.0722**	-0.00611
	(-2.06)	(-0.95)
Size^2	0.00193	0.000246
	(1.45)	(0.94)
Net interest margin	-1.178*	1.486***
	(-1.89)	(6.08)
Fee income	-0.655***	0.195***
	(-9.84)	(2.79)
Wholesale funding	-0.139**	-0.0877***
	(-2.52)	(-4.86)
Non-interest expenses	-3.198***	-1.155***
	(-10.87)	(-3.79)
Market share	-0.0843	-0.0870
	(-0.42)	(-1.44)
Aggregate credit	2.704***	-0.0260
	(18.91)	(-0.55)
Basel II	-0.0308	0.00401
	(-0.67)	(0.39)
RGDP growth	6.694***	-0.133
	(7.76)	(-0.60)
CPI	-2.465***	-0.362**
	(-4.25)	(-2.01)
Gvt Debt/GDP	-0.450***	-0.000465
	(-10.00)	(-0.02)
GDP per capita	0.0401	-0.00424
	(1.50)	(-0.37)

Exchange rate chg	1.464***	0.0565
	(4.30)	(1.52)
Activity restrictions	-0.163***	-0.00656***
	(-26.37)	(-3.07)
Regulatory stringency	0.0191	0.00456
	(1.48)	(0.94)
Capital requirements	0.744	-0.583
	(0.39)	(-0.94)
Creditor rights	0.0300**	0.00123
	(2.23)	(0.22)
Constant	3.475***	0.159
	(7.33)	(0.75)
Observations	147782	128622
Adjusted R^2	0.165	
Number of instruments		54
AR(1) test p value		0.000
AR(2) test p value		0.000
AR(3) test p value		0.692
Hansen test p value		0.377
CIT (Long run)		4.057
		(1.08)

Chapter 5

Financial Repression or Risk Shifting? Determinants and Valuation Effects of the Home Bias in European Banks' Sovereign Debt Portfolios

Abstract We document that the largest European banks hold sovereign debt portfolios heavily biased toward their domestic governments. This bias is stronger if (1) both the sovereign and the banks are weak, (2) the sovereign is weak and shareholder rights are strong, and (3) the sovereign is weak and the government has positive ownership in the bank. We also find that the home bias is positively valued by the market as reflected by a positive association between the home bias and Tobin's q. The home bias premium is small when public finances are weak –keeping bank risk constant, but when both the sovereign and the banks are weak, the premium is positive. These results provide evidence for both the voluntary hoarding and government repression channels.

5.1. Introduction

The recent European sovereign debt crisis revealed the interrelatedness of the financial sector and government finances to be a key issue. Specifically, large holdings of domestic sovereign debt by banks may have a detrimental effect on financial and macroeconomic stability. Banks that are heavily exposed to their domestic government stand to suffer heavy losses in case of a domestic sovereign default, making costly distress in the financial sector more likely. A government bail-out of distressed banks, in turn, reduces the financial strength of the government, increasing yields on government debts and reducing their valuation. This further weakens the financial sector if financial institutions are heavily exposed to domestic government debt (see Acharya et al., 2014).

The strength of the potentially negative feedback loop between the financial and government sectors would be reduced, if banks were less exposed to domestic government debt. This renders it important to understand the determinants of banks' tendency to hold relatively much domestic government debt. This paper provides empirical evidence on the determinants of the observed home bias towards domestic sovereign debt, and of its implications for bank valuation. Importantly, this work provides tests that can help discriminate among competing explanations of the home bias.

Two main motivations for a bank's home bias towards domestic government debt have been advanced. First, banks may benefit from holding extensive domestic government debt, if this enables them to increase overall bank risk and shift risk to the banks' creditors. Domestic government debt may be especially attractive in this regard, as banks may reason that they will fail anyway when their domestic sovereign defaults. A home bias towards domestic government debt then benefits shareholders, if the bank's cost of funds does not fully reflect the heightened losses in case of a sovereign default, due to, for instance, the existence of deposit insurance or the availability of cheap central bank funding.

A second main explanation of the home bias has to do with the fact that governments use bank regulation and supervision to induce banks to hold extensive domestic government debt. The zero-risk weighting attached to domestic government debt in the Basle capital adequacy framework, in particular, provides an inducement for banks to expose themselves heavily to domestic government debt.

In this paper, we examine the domestic debt home bias for the sample of European banks that were subject to a series of stress tests over the 2010-2013 period conducted by the European Banking Authority (EBA), and its predecessor, the Committee of European Banking Supervisors (CEBS). This set of banks includes the largest publicly traded European banks.

We examine the determinants of the home bias by estimating regressions of any bank's exposure to any EU government's debt – relative to bank assets. We find that a bank's home bias is stronger, if domestic country risk – as proxied by the domestic sovereign CDS spread – is higher and if bank risk is higher – as proxied by bank leverage. These results suggest that higher risk on the part of either the government or the bank serves to intensify the link between the financial sector and government finances, increasing the chance of joint bank and sovereign failure. While significant, these results by themselves do not enable us to discriminate between the 'risk-shifting' and 'government-action' explanations of the home bias, as both are consistent with a greater home bias in the case of higher country or bank risk.

Three additional results, however, provide more pointed evidence on the relative merits of the explanations of the home bias. First, as evidence in support of a 'government action' explanation of the home bias, we find that the home bias is greater in case of a risky sovereign especially for government-owned banks. Governments have greater sway over publicly owned banks, and hence can more easily induce these banks to increase their funding to a risky sovereign.

Second, as evidence of the 'risk-shifting' explanation, we find that the home bias is greater for a risky sovereign, if the bank-level corporate governance regime is more shareholder-friendly. Risk-shifting by way of an increased exposure to a risky sovereign serves the interests of bank shareholders consistent with the risk-shifting hypothesis, possibly at the expense of bank creditors, management and employees.

Third, we find that bank valuation, as proxied by a bank's Tobin's q, is positively related to a measure of the home bias towards domestic government debt, consistent with a risk-shifting explanation. However, we find that the positive valuation effect of the home bias declines with the domestic sovereign's CDS spread. A lower valuation of the home bias with a more risky sovereign suggests that banks involuntarily take on the debts of riskier domestic sovereigns – consistent with a government-action explanation.

There are several papers that have previously investigated banks' bias towards domestic sovereign debt. Angeloni and Wolff (2012) document a home bias using the sovereign debt exposure data released by the EBA in July and December 2011. We document the home bias including data up to 2013. Battistini et al. (2014) examine the home bias using monthly, disaggregated, country level data on banks' sovereign debt exposure. They conclude that banks respond to higher country risk by increasing their domestic debt exposure (although only in the case of periphery – i.e. already risky –

countries), consistent with the main competing explanations of the home bias. Going beyond Battistini et al. (2014), this paper provides evidence of the main explanations of the home bias separately.

Related to the previous papers, Acharya and Steffen (2015) present evidence of banks' use of European government bonds to reap carry trade profits. They show that bank stock returns positively correlate with the returns on Greek, Italian, Irish, Portuguese and Spanish (GIIPS) long-term government bonds and negatively with northern (German) bond returns. These patterns are consistent with banks holding large GIIPS government bond portfolios financed by selling German government debt. The authors show that this behavior is related to governments pressurizing banks to absorb domestic debt; and to regulatory arbitrage and/or risk-shifting by under-capitalized banks. We extend their results by providing further tests to distinguish between these channels.

There are some theoretical results regarding banks' home bias incentives. Uhlig (2014) argues that in a monetary union, where banks can pledge government bonds to obtain central bank financing, regulators in risky countries allow banks to hold more risky domestic government debt. This way risky countries shift risk onto the central bank of the union, and eventually to other, safe countries. This leads to biased government bond portfolios in risky countries. Our results confirm Uhlig's prediction that the home bias is stronger in riskier countries and in riskier banks.

The home bias literature is embedded in a broader discussion about the interrelatedness of bank stability and public finances (cf. BIS, 2011) and as such our paper is related to papers investigating how government finances affect financial stability and vice versa. Systemically important banks (or groups of banks) enjoy implicit and explicit bailout guarantees, which distort their incentives. However, these subsidies are shown to depend on the fiscal strength of the government (Demirgüç-Kunt and Huizinga, 2013; Horváth and Huizinga, 2015): as countries become weaker, bank valuation also declines and bank default risk increases. Attinasi et al. (2009) and Ejsing and Lemke (2009) show that prior to bank bailouts, country and bank risk moved strongly together and bank bailouts represented a risk transfer from the banking sector to the sovereign. Acharya et al. (2014) provide further evidence for the two-way feedback between the government and the banking sector. These papers estimate the aggregate effect of various channels: the effect of ongoing bailouts, changes in the value of banks' government debt exposure and changes in the value of explicit and implicit government guarantees. Our paper adds to this literature by pinning down one channel through which the feedback materializes.

We also contribute to the literature on the optimal institutional setup of a monetary union. The literature identified a trade-off regarding banks' government bond holdings: more integration yields diversification benefits, but it also increases the risk of contagion (Bolton and Jeanne, 2011; Korte and Steffen, 2014). We show that banks may not fully take advantage of diversification benefits due to regulatory pressure or because of bad incentives.

We proceed in the next section by describing the hypotheses of the paper and introduce the methodology to test the hypotheses. In Section 5.3 we describe the data used in the paper. In Section 5.4 we present the results. Section 5.5 provides a discussion of the results and concludes.

5.2. Hypotheses regarding the home bias and empirical approach

In the literature, several competing explanations are offered for the tendency of banks to allocate a relatively large portfolio share to domestic government debt. First, banks that invest heavily in domestic government debt potentially face heavy losses in the event of a default of the domestic sovereign. Increased losses in this event do not further harm bank shareholders, if the bank is going to fail anyway in the event of a domestic sovereign default. Banks are able to shift risk of joint bank and sovereign failure to tax payers and possibly to bank creditors to the extent that a bank's funding cost does not properly reflect the cost of joint failure, due to deposit insurance or because of the availability of cheap central bank funding. In the Eurozone, banks have been able to obtain ample and cheap credit from the ECB through the Long-Term Refinancing Operation (LTRO) facility starting in the end of 2011. The cost of this financing, at 1% annually at the time of announcement, does not reflect any additional bank risks resulting from increased domestic government debt exposures financed by this funding.

Second, bank's sovereign debt portfolios may display a home bias, as banks are induced to invest heavily in domestic government debt by government action. An important inducement is the zero risk weighting attached to government debt by Basle capital adequacy rules. Occasionally individual governments use other regulatory inducements to banks to invest in domestic government debts as well. On April 24, 2014, for instance, the Hungarian central bank announced various measures with the stated aim of improving Hungary's debt structure. These measures, including a new interest rate swap facility, were explicitly designed to facilitate the purchase of Hungarian debt by Hungarian banks by increasing incentives for them to hold domestic as opposed to foreign government bonds.

A third motivation has to do with the fact that exposure to domestic government debt can provide domestic banks with a natural hedge against the risk of Eurozone break-up. The idea is that after such a break-up domestic government debt is likely to be denominated in the same currency as main funding categories such as bank deposits, thereby reducing redenomination risk (see Battistini et al., 2014).

To examine the validity of these hypotheses, our empirical work consists of two parts: (i) portfolio share regressions with as the dependent variable the ratio of bank's sovereign debt exposure to any EU country relative to the bank's total assets, and (ii) bank valuation regressions with as the dependent variable a bank's Tobin's q constructed as the approximated market value of the bank's assets relative to their book value.

The risk-shifting motive for a home bias would predict that the home bias is larger in case of a risky sovereign (in the empirical work, we will use the sovereign CDS spread for 5-year contracts to proxy for country risk), as then bank risk can be increased materially by a higher share of domestic government debt in the sovereign debt portfolio. However, the government action hypothesis to explain the home bias is also consistent with a positive impact of country risk on a bank's domestic debt holdings, as weak governments presumably have a greater need for using their domestic banks as a funding source. Finally, the natural hedge hypothesis can also explain a greater home bias for banks located in a risky country, as a country's sovereign default risk can be expected to correlate with redenomination risk. Overall, we thus expect a positive relationship between the sovereign debt home bias and country default risk, even if evidence to this effect does not enable us to establish the relative merit of competing hypotheses of the home bias.

We further relate sovereign debt shares to bank leverage as a proxy for bank risk. Risky banks have a risk-shifting motive for a government debt bias as they stand a real chance of bank failure. Riskier and weaker banks may similarly be easier to cajoled into holding additional domestic government debt by a government intent on increasing its bank funding. A positive relationship between bank risk and the home bias thus does not enable us to discriminate between the risk-shifting and government action rationales for the home bias.

We use information on bank ownership and bank-level corporate governance regimes to test more specific hypotheses concerning the channels underlying the sovereign debt home bias. First, we hypothesize that banks hold more government debt of risky governments if the bank is government-owned. This would be evidence in support of the government action channel, as governments are more capable of nudging banks towards a higher portfolio share of domestic government debt if they are government-owned. Second, we examine whether banks hold more domestic government debt of risky countries especially if the bank's corporate governance regime is rather shareholder-friendly. Evidence of this kind supports the risk-shifting motive for the home bias as risk-shifting benefits shareholders at the expense of other stakeholders such as the bank's creditors and possibly its management and employees.

In addition to the portfolio share analysis, we consider the implication of a bank's home bias in its government debt portfolio on bank valuation. To this end, we construct a home bias variable that reflects to what extent a bank's share of domestic government debt in its overall government debt portfolio exceeds the average share of that country's government debt in EU banks' government debt portfolios. A positive valuation of a bank's home bias by bank shareholders is consistent with the risk-shifting and natural hedge motives for such a bias, while a negative valuation suggests that banks are nudged or forced to hold more domestic debt than they wish consistent with a government action explanation. A valuation of the home bias that increases with country risk similarly is consistent with the risk-shifting and natural hedge hypotheses, while a valuation of the home bias that declines with sovereign risk suggests that banks are forced to hold too much domestic government debt in case of a risky sovereign consistent with a government-action explanation of the home bias.

5.3. Data

We obtain data on banks' exposures to government debts of EU member states from the EU-wide stress tests conducted first by the Committee of European Banking Supervisors for the first quarter of 2010, and subsequently by the European Banking Authority for the fourth quarter of 2010, the fourth quarter of 2011, the second and fourth quarters of 2012, and the second quarter of 2013. The first stress test of 2010 included 91 banks, representing 65% of the European banking market in terms of assets. Subsequent stress tests involved mostly the same set of banks. Our sovereign debt exposure data are net of impairment and cover debt in both the banking and trading books. Moreover, the exposure data are net of derivative positions. As a consequence, the exposure data are potentially negative. This is the case in about 1% of the observations.

Using the exposure data, we construct the sovereign exposure variable as a bank's exposure to any one EU sovereign divided by bank total assets (with bank balance sheet information taken from SNL Financials; Appendix 5.6 provides variable definitions and data sources). As seen in Table 5.1, the sovereign exposure variable has a mean of 0.3%, meaning that a bank's average sovereign debt exposure to any EU country is about 0.3% of total assets. The maximum value of the sovereign exposure variable is 0.321 (for the case of a Greek bank's exposure to Greek sovereign debt).

In Figure 5.1 we plot banks' exposure to domestic government debt as a percentage of their total assets. We report the mean values for three GIIPS countries (Italy, Portugal and Spain)[32] and non-GIIPS banks separately. Throughout the sample period banks in GIIPS countries have higher exposures to domestic government debt than banks in non-GIIPS countries. However, this difference becomes dramatically more pronounced after the second quarter of 2012, with banks in GIIPS countries increasing significantly their exposures to domestic government debt. Around the same time, banks in non-GIIPS countries increased their exposures to domestic government debt as well, but to a lesser degree. This increase in domestic government debt, particularly from banks in GIIPS countries, may reflect the introduction of LTRO by the ECB in December 2011. Prior to LTRO, banks in GIIPS countries had limited access to liquidity and their funding costs

[32]We exclude Greece from the graph, because exposure data for Greek banks is not available for the fourth quarter of 2011 and the second quarter of 2012. Ireland is excluded because of missing balance sheet data for Irish banks.

were sensitive to the risk of their portfolios. With the introduction of LTRO banks in the Eurozone were able to access liquidity at very low costs and costs that were not sensitive of their risk or the risk of any additional investments. Figure 1 indicates that banks in GIIPS countries may have used the liquidity from LTRO to increase their exposure to domestic government debt.[33]

The underlying bank exposure data are also used to construct a measure of the home bias of a bank's sovereign debt portfolio following Bracke and Schmitz (2008). Let E_{ijh} be the exposure of bank i to the sovereign debt of country j given that the bank is located in country h. The share, S_{ijh}, of bank i's government debt portfolio allocated to country j can be written as follows

$$S_{ijh} = \frac{E_{ijh}}{\sum_j E_{ijh}}. \tag{5.1}$$

Actual portfolios shares, S_{ijh}, allocated to the debt of country j can be compared to the portfolio share, $CAPM_j$, for country j that would arise if all banks were to invest in sovereign debts in proportion to debts outstanding as follows

$$CAPM_j = \frac{\sum_i E_{ijh}}{\sum_i \sum_j E_{ijh}}, \tag{5.2}$$

where h takes on different values for banks located in different countries.

The home bias, HB_{ih}, for a bank i located in country h is defined as 1 minus the ratio of the bank's portfolio share allocated to non-h countries divided by the share of the available debts of non-h countries as follows

$$HB_{ih} = 1 - \frac{\sum_{i \neq h} S_{ijh}}{\sum_{j \neq h} CAPM_j}, \tag{5.3}$$

or equivalently

$$HB_{ih} = 1 - \frac{1 - S_{ijh}}{1 - CAPM_h}. \tag{5.4}$$

[33] Distinguishing between the various GIIPS countries reveals that this increase is more pronounced for Italy and Portugal. Analyzing the available data for Greek bank reveals an overall declining exposure to domestic government debt due the assumption of Greek debt by European official bodies.

The home bias HB_{ih} for bank i is zero if the bank's actual portfolio share allocated to its home country h, S_{ijh}, equals the available debt share for that country, i.e. $CAPM_h$, while $HB_{ih} > 0$ if $S_{ijh} > CAPM_h$, and vice versa. The sample mean value of HB is positive at 0.613.

In Figure 5.2 we plot the sample averages of the home bias variable separately for banks located in three GIIPS countries (Italy, Portugal and Spain), and banks in non-GIIPS countries. The figure shows that throughout the sample period the sovereign debt portfolios of banks in GIIPS countries were significantly more biased towards their domestic governments than the portfolios of banks in non-GIIPS countries. Furthermore, the home bias in non-GIIPS countries increased materially over the 2010-2012 period and it began decreasing for both groups of banks after July 2012. This reduction in the home bias towards the end of the sample period together with the increase in domestic government debt documented in Figure 5.1 suggest that banks in GIIPS countries may have used the LTRO facility to also expand their exposures other countries' government bonds, engaging in a carry trade, as well as non-GIIPS-based banks' higher willingness to buy GIIPS assets. Banks in non-GIIPS countries, exhibit qualitatively a similar behavior, but to a lesser degree.

In the portfolio regressions, the sovereign exposure variable is first related to the domestic variable which is a dummy variable signaling domestic sovereign debt. To represent country risk, we use the sovereign CDS spread for 5-year senior sovereign debt available from Datastream. As an index of bank risk, leverage is the total liabilities divided by total assets, with a mean of 0.942.

In some specifications, we consider how a bank's sovereign debt portfolio decision depends on the share of government ownership taken from SNL Financials. On average, the share of government ownership is 5.4%.

In addition, we consider the impact of bank-level corporate governance. We use indices of corporate governance as formulated by Aggarwal et al. (2010). The indices increase with the power of minority shareholders, and are based on individual governance attributes assembled by Institutional Shareholder Services. The individual characteristics are dummy variables that take on a value of 1 if the attribute is relatively shareholder-friendly, and zero otherwise. The corporate governance variable is an overall index that summarizes information on the full set of 44 attributes. Furthermore, there are four sub-indices, called board, compensation and ownership, auditing and takeover that summarize information on 25, 10, 3 and 6 attributes related to the pertinent aspects of corporate governance. The takeover sub-index, for instance, reflects the extent to which there are corporate governance-related barriers to takeovers.

In the valuation regressions, Tobin's q is computed as the market value of equity plus the book value of total liabilities divided by the book value of total assets. The average Tobin's q is 0.984. This bank valuation measure is first related to the assets variable which is the logarithm of total assets. Larger banks may attain higher market valuation as a reflection of their too-big-to-fail status. Deposits to liabilities is the ratio of total deposits to total liabilities with a mean of 0.5. Deposits funding may increase bank valuation as it is relatively cheap and stable. The return on equity is the ratio of operating income to equity, with a mean of 0.11. A higher return on equity may be mirrored in a higher Tobin's q.

The income diversity variable measures to what extent a bank's income is diversified between net interest income and non-interest income. Specifically, this variable takes on a value of 1 if net interest income and non-interest income are equal (in this case the bank's income is taken to be well-diversified), while it declines with the absolute value of the difference between these the two types of income. Similarly, the asset diversity variable equals 1 if its loans and securities portfolios are of equal size, while it decreases with the divergence in the size of these two bank asset categories. Banks with highly diverse income streams or asset portfolios may possibly be valued less, as they are more difficult to manage effectively (Laeven and Levine, 2007).

Finally, the asset growth variable is the rate of change of a bank's assets, while the operating income growth variable is the growth rate of a bank's operating income. Banks with growing assets or operating income may be valued more highly as a reflection of growth opportunities as perceived by bank stock investors. Table 5.2 provides information on correlations among the bank-level variables. The table shows that Tobin's q and the home bias have a positive correlation of 0.0508, but this correlation is not statistically significant.

5.4. Empirical results

5.4.1. Portfolio share regressions

The portfolio share regressions explain a bank's sovereign exposure to any of the EU governments as a share of the bank's total assets. In regression 1 of Table 5.3, the sovereign exposure variable is related only to the domestic dummy variable. The regression includes bank and time fixed effects, and errors allow for clustering at the bank level. The domestic variable obtains a coefficient of 0.059 that is significant at the 1% level. This confirms a positive home bias towards bank investments in domestic government debt as displayed in Figure 1. The coefficient of 0.059 implies that a bank's exposure to domestic government debt is on average almost 6% of assets higher than for any foreign government. This home bias is economically significant as the sovereign exposure variable has a mean of only 0.3% with a standard deviation 1.5% as seen in Table 5.1. In regression 2, we include country-time fixed effects instead of time fixed effects, again yielding a coefficient of 0.059 for the domestic variable that is significant at the 1% level. Including bank-time fixed effects, as in regression 3, similarly yields results that are virtually unchanged.

Next, we examine how the home bias is affected by country risk as represented by the sovereign CDS spread, and by bank risk as represented by bank leverage. Starting with country risk only, regression 1 in Table 5.4 includes an interaction term of domestic with the sovereign CDS spread in addition to bank and country-time effects (the inclusion of the latter fixed effects precludes an estimation of the effect of the sovereign CDS spread per se on the portfolio share). The interaction term obtains a positive coefficient of 0.016, but it is statistically insignificant. Regression 2 instead includes bank-time effects yielding almost identical results.

Next, regressions 3 and 4 additionally include the leverage variable, interactions of this variable with domestic and sovereign CDS, and a triple interaction of this variable with domestic and the sovereign CDS spread, starting from regressions 1 and 2. In regression 3, the interaction of domestic and sovereign CDS obtains a negative coefficient of -0.301 that is significant at the 10% level, while the triple interaction of domestic, sovereign CDS and leverage has a positive coefficient of 0.332 that is significant at the 10% level. These two estimated coefficients together imply that the home bias declines with the sovereign CDS spread for lowly leveraged banks and vice versa. Specifically, the home bias declines with the sovereign CDS spread if leverage is below 0.907, and vice versa. A bank with average leverage of 0.942 is estimated to increase its home bias with the sovereign CDS spread.

The tendency for the home bias to decline with the sovereign CDS spread for lowly leveraged banks suggests that such banks try to diversity away part of the risk associated with highly risky domestic government debt. Highly leveraged banks instead increase their domestic exposure with the riskiness of domestic government debt consistent with the risk-shifting as well as the government action hypotheses.

In regressions 3 and 4, the domestic variable and its interaction with leverage are highly correlated leading to collinearity. Regressions 5 and 6 are similar to regressions 3 and 4 but exclude the interaction of the domestic and leverage variables. In these regressions, the domestic variable is estimated with a positive coefficient that is significant at the 1% level, while its interactions with the sovereign CDS spread, and jointly with the sovereign CDS and leverage, obtain negative and positive coefficients, respectively, that are both significant at the 5% level. Estimated coefficients in regressions 5 and 6 imply that the home bias increases with the sovereign CDS spread for banks if leverage is greater than 0.832 (=0.099/0.119) and 0.825 (=0.099/0.120), respectively. This applies to all banks in the sample, as the minimum leverage is 0.848 from Table 5.1.

Next we consider how the home bias depends on the government ownership share in a bank. Governments have greater control over government-owned banks than over privately owned banks, and hence a greater home bias for government-owned banks in case of a risky sovereign suggests that governments force these banks under their control to hold more government debt. Regressions 1 and 2 of Table 5.5 includes an interaction between domestic and the government ownership share in regressions 1 and 2 of Table 5.4, yielding positive coefficients that are statistically insignificant. The government ownership share is time-invariant, and hence subsumed by the bank fixed effects in these regressions. Regressions 3 and 4 additionally include a triple interaction term of domestic, the sovereign CDS spread, and the government ownership share. In these regressions, the domestic variable, its interaction with the sovereign CDS spread, and the triple interaction term obtain positive coefficients that are statistically significant at 1%, 10%, and 1%, respectively. Hence, the home bias increases with country risk as proxied by the sovereign CDS spread, and it is especially strong in case of both high country risk and a high government ownership share of the bank. The latter result could imply that governments force their government owned banks to purchase domestic government debt especially if country risk is high, and hence is consistent with a government action explanation of the home bias.

A home bias with a risk-shifting motive serves the interests of shareholders. Thus we may expect a greater home bias towards a risky sovereign if the corporate governance of the bank is relatively shareholder-friendly. To examine the impact of corporate governance, we first include interactions of domestic and corporate governance in regressions 1 and 2 of Table 5.4, with the results reported as regressions 1 and 2 of Table 5.6. Estimated coefficients for this interaction term are negative but statistically insignificant. Regressions 3 and 4 in addition include triple interactions of domestic, and sovereign CDS spread, and corporate governance. In both regressions, this triple interaction term is estimated with a positive coefficient that is significant at the 1% level. The home bias towards the debts of risky domestic sovereigns thus appears to be strong especially if corporate governance is shareholder-friendly. This is evidence in favor of a risk-shifting motive for the sovereign debt home bias.

The overall corporate governance index can be broken down into four subindices that represent corporate governance attributes related to the board, auditing, takeover matters, and compensation and ownership. To examine the separate roles of these aspects of corporate governance, we include these one at a time in regressions 1-4 of Table 5.7, analogously to regression 4 of Table 5.6. The triple interactions of the board, audit and takeover subindices with domestic and sovereign CDS obtain positive and significant coefficients in columns 1-3, while the triple interaction of compensation and ownership with domestic and sovereign CDS spread obtains a negative but insignificant coefficient in regression 4. Regression 5 in turn includes the triple interactions involving the four subindices jointly. In this instance, the triple interaction involving the board subindex is estimated with a positive and significant coefficient, while the other three triple interactions are estimated with insignificant coefficients. This suggests that board attributes that are shareholder-friendly particularly contribute towards a home bias towards risky sovereigns, consistent with a risk-shifting motive.

5.4.2. Bank valuation regressions

This subsection examines the implications of the sovereign debt home bias in banks' portfolios on bank valuation, as proxied by Tobin's q. The relationship between bank valuation and the home bias potentially provides us with additional information on the underlying determinants of the home bias. A positive valuation of the home bias should arise if banks invest in domestic government bonds with a view to shifting risks. A home bias which is valued negatively by bank stock investors, on the other hand, is consistent with banks beings forced in one way or another by their governments to invest in domestic government debt.

To start, we relate Tobin's q to the home bias variable in a regression that includes bank and country-time fixed effects. The estimated coefficient for the home bias variable, as reported in column 1 of Table 5.8, is positive at 0.00687 and significant at the 5% level. A bank with average home bias of 0.613 thus is estimated to have a Tobin's q that is 0.4% (= 0.613*0.00687) higher, consistent with a risk-shifting explanation of the home bias. In regression 2, we include a set of control variables in regression 1 to control for time-varying bank characteristics. The home bias variable obtains a positive coefficient of 0.0057 that is significant at the 1% level. Among the controls, Tobin's q is positively and significantly related to leverage, while it is negatively and significantly related to bank size as measured by total assets.

Regressions 3 and 4 include an interaction term of the home bias and sovereign CDS variables in regressions 1 and 2. The coefficients on these interaction terms are negative and statistically significant at the 1% level in regression 4. The home bias thus is relatively negatively valued if the home country is more risky. This suggests that banks in risky countries are forced to increase their home bias beyond the level consistent with maximum bank valuation.

Regressions 5 and 6 additionally include interaction terms with leverage. The interactions of home bias with sovereign CDS continue to have negative and significant coefficients, while the triple interaction terms between home bias, sovereign CDS, and leverage have positive coefficients. Banks thus stand to benefit more from a home bias, if the country and the bank are both risky. This is consistent with the notion that risk-shifting by risky banks through a higher home bias increases bank valuation. The coefficient of leverage is positive and statistically significant, while its interaction term with sovereign CDS spread is negative and statistically significant indicating that banks with higher leverage are positively valued unless they are located in riskier countries.

Regressions 7 and 8 exclude the home bias and leverage interaction variable from regressions 5 and 6 on the ground that this variable is highly correlated with home bias. Results with respect to the interaction terms remain unchanged, while the coefficient of the home bias variable gains statistical significance. Finally, regressions 9 to 12 present augmented specifications of the previous four regressions including the sovereign debt exposures to each country as a percentage of the bank's total sovereign debt portfolio. This allows to additionally control for differences in the pricing of different government bonds on Tobin's q. A similar approach was used, for example, in Huizinga and Laeven (2012). Results are unaffected.

Overall, our findings in Table 8 indicate that home bias is positively valued, particularly if both the country and the bank are risky. Home bias in risky countries is otherwise negatively valued suggesting that less risky banks in risky countries may be forced to hold more domestic government debt than what is consistent with maximum bank valuation.

Next, we examine how the value of home bias varies over time. In Table 9 we estimate separate valuation regressions for each of the six stress tests dates in our sample. Using the estimates from these specifications we compute the marginal value of home bias on each of these dates (the first derivative of Tobin's q with respect to the home bias variable). Figure 3 displays the resulting marginal values. We report the estimated mean values and their 95% confidence intervals. As can be observed in Figure 3, prior to LTRO, home bias had on average a positive marginal valuation (i.e., an increase in the average bank's home bias was associated with an increase in the average bank's value). After LTRO, the average marginal value of home bias declined significantly as the crisis became less severe over time. In combination with results in Figures 1 and 2, these results indicate that despite the positive marginal value of home bias during the first part of the sample, banks could increase their domestic government debt exposures only marginally. The introduction of LTRO increased banks' access to cheap liquidity. This allowed banks, and in particular banks in riskier countries, to expand their holdings of domestic government debt, which in turn brought down the marginal value of home bias as the crisis began to subside and spreads in risky government bonds began to drop.

5.5. Policy implications and conclusions

In this paper we analyzed banks' sovereign debt portfolios and found that there is a significant bias towards domestic government debt. This poses threats to financial stability in countries where sovereign default is perceived as a real possibility and can have implications for macroeconomic stability through its impact on credit supply (Popov and Van Horen, 2014). This is all the more troubling since the bias is largest in countries where the risk of sovereign and bank default are the highest.

When we look deeper at the composition of banks' sovereign debt portfolios we find support for two hypotheses of home bias: more government ownership is associated with larger home bias in weak countries, supporting the government action story; while more shareholder-friendly corporate governance is positively correlated with the home bias in weak countries, in line with the risk-shifting explanation. The bank valuation regressions corroborate these results. We find a premium associated with a government bond portfolio tilted towards the domestic sovereign. This premium declines with sovereign CDS spreads, but less so for highly leveraged banks, suggesting that the risk-shifting and government suasion channels are both operative.

These results provide a rationale for mitigating the risk of interconnected government finances and bank stability by way of encouraging less biased sovereign debt portfolios. Applying positive risk weights for sovereign debt is one such avenue. Risk weights that increase with the likelihood of default should reduce banks' incentives to shift risk to creditors and tax payers by increasing the cost of loading on risky domestic government bonds. Risk weights may also limit governments' willingness to force banks to absorb their debt as such an action would weaken banks' regulatory capital position and would risk a credit crunch exactly at a time when banks already face difficulties in meeting capital requirements.

Further integration of bank supervision at the European level should also be considered, since one way governments can induce banks to absorb sovereign debt is by applying regulatory forbearance for banks under domestic oversight. A common European supervisory framework could alleviate such concerns by removing the tools from local governments' hands. In this respect bank stakeholders will benefit from the recent creation of eurozone level regulatory and supervisory bodies, such as the EBA and the European Systemic Risk Board.

5.6. Appendix

Table 5.A1: Variable definitions and source of data

Variable	Description	Source
Sovereign exposure	Bank's holdings of EU government debt to total assets	EBA, CEBS, SNL Financial
Home bias	1 minus the ratio of a bank's sovereign debt portfolio share allocated to foreign EU countries divided by the share of foreign EU country sovereign debt in all EU sovereign debt held by banks in the sample	EBA, CEBS
Domestic	Dummy variable indicating domestic sovereign debt exposure	EBA, CEBS
Sovereign CDS	CDS spread for five-year senior sovereign debt (in basis points/10,000)	Datastream
Leverage	Total liabilities divided by total assets	SNL Financial
Government ownership	Share of domestic government ownership of a bank	SNL Financial
Corporate governance	Overall corporate governance index	ISS
Board	Corporate governance index based on board attributes	ISS
Audit	Corporate governance index based on auditing attributes	ISS
Takeover	Corporate governance index based on antitakeover attributes	ISS
Competition and ownership	Corporate governance index based on compensation and ownership attributes	ISS
Tobin's q	Tobin's Q computed as market value of equity plus book value of liabilities divided by book value of assets	Datastream, SNL Financial
Assets	Logarithm of total assets	SNL Financial
Deposit to liabilities	Total deposits divided by total liabilities	SNL Financial
Return on equity	Operating income divided by total equity	SNL Financial

Income diversity	1-Abs((Net interest income - (Net noninterest income))/Total operating income)	SNL Financial
Asset diversity	1-Abs((Net loans - Total securities)/(Net loans +Total securities))	SNL Financial
Asset growth	Quarterly rate of change of total assets	SNL Financial
Operating income growth	Growth rate of operating income	SNL Financial

5.6.1. Corporate governance attributes

Board attributes

1. All directors attended 75% of board meetings or had a valid excuse
2. CEO serves on the boards of two or fewer public companies
3. Board is controlled by more than 50% independent outside directors
4. Board size is greater than 5 but less than 16
5. CEO is not listed as having a related-party transaction
6. No former CEO on the board
7. Compensation committee composed solely of independent outsiders
8. Chairman and CEO are separated or there is a lead director
9. Nominating committee composed solely of independent outsiders
10. Governance committee exists and met in the past year
11. Shareholders vote on directors selected to fill vacancies
12. Governance guidelines are publicly disclosed
13. Annually elected board (no staggered board)
14. Policy exists on outside directorships (four or fewer boards is the limit)
15. Shareholders have cumulative voting rights
16. Shareholder approval is required to increase/decrease board size
17. Majority vote requirement to amend charter/bylaws
18. Board has the express authority to hire its own advisors
19. Performance of the board is reviewed regularly
20. Board-approved succession plan in place for the CEO
21. Outside directors meet without CEO and disclose number of times met
22. Directors are required to submit resignation upon a change in job
23. Board cannot amend bylaws without shareholder approval or can do so only under limited circumstances
24. Does not ignore shareholder proposal
25. Qualifies for proxy contest defenses combination points

Auditing attributes

26. Board independence: Audit committee
27. Consulting fees paid to auditors are less than audit fees paid to auditors
28. Auditors ratified at most recent annual meeting

Antitakeover attributes

29. Single class, common
30. Majority vote requirement to approve mergers (not supermajority)
31. Shareholders may call special meetings
32. Shareholder may act by written consent
33. Company either has no poison pill or a pill that was shareholder approved
34. Company is not authorized to issue blank check preferred

Compensation and ownership attributes

35. Directors are subject to stock ownership requirements
36. Executives are subject to stock ownership guidelines
37. No interlocks among compensation committee members
38. Directors receive all or a portion of their fees in stock
39. All stock-incentive plans adopted with shareholder approval
40. Options grants align with company performance and reasonable burn rate
41. Company expenses stock options
42. All directors with more than one year of service own stock
43. Officers' and directors' stock ownership is at least 1% but not over 30% of total shares outstanding
44. Repricing is prohibited

Source: Aggarwal et al. (2010)

5.7. Figures

Figure 5.1: Banks' exposure to domestic government debt in GIIPS and non-GIIPS countries

The graph displays the average domestic government debt to total assets ratios for banks in three GIIPS countries (Italy, Portugal and Spain) and non-GIIPS countries.

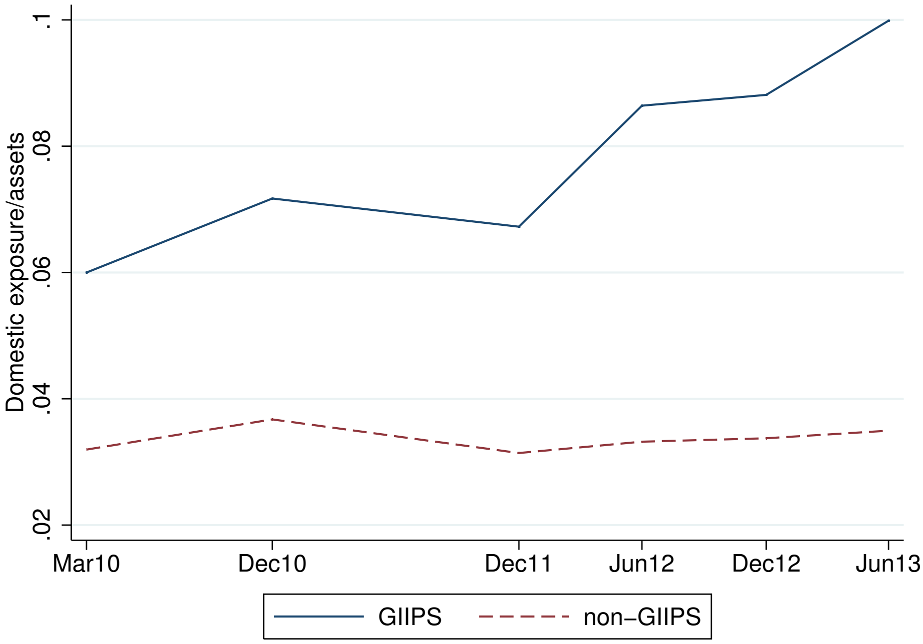


Figure 5.2: Average home bias for GIIPS and non-GIIPS countries

The home bias is calculated as 1 minus the ratio of a bank's sovereign debt portfolio share allocated to foreign EU countries divided by the share of foreign EU country sovereign debt in all EU sovereign debt held by banks in the sample. GIIPS countries in this graph include Italy, Portugal and Spain.

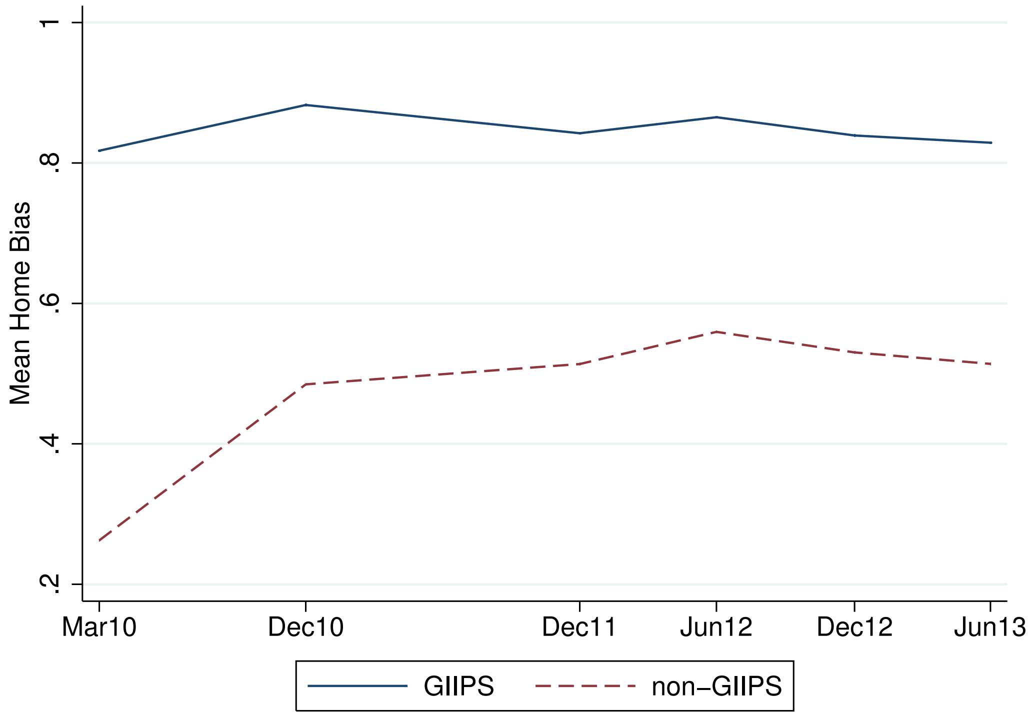
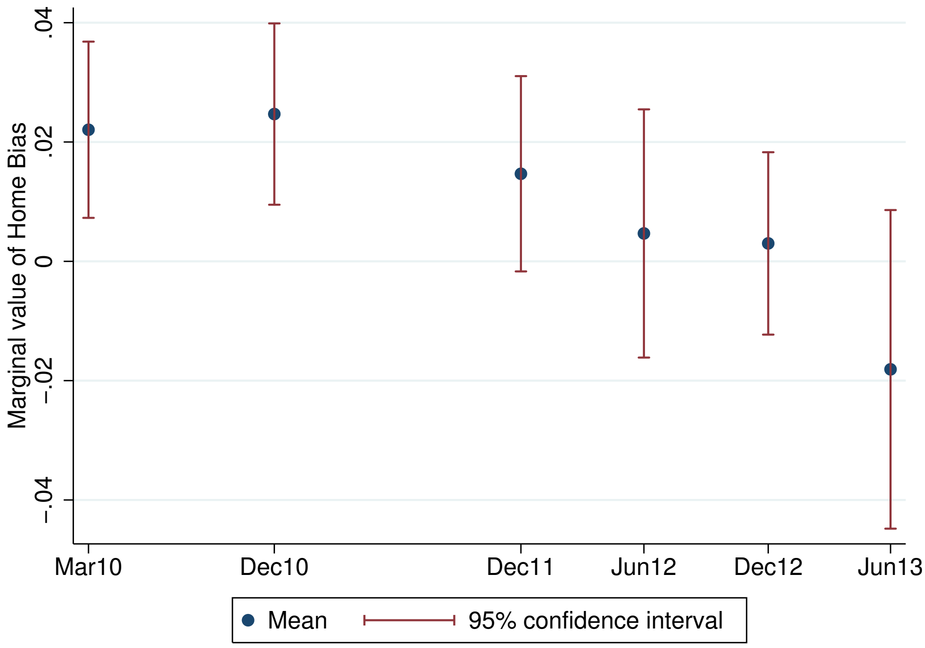


Figure 5.3: Marginal value of home bias during the sample period

The graph displays the average marginal value of home bias during the sample period and the 95% confidence intervals around the estimated mean values. The estimates are obtained using the estimated coefficients of the Tobin's q regressions in Table 9, calculated using the first derivative of these regressions with respect to the home bias variable.



5.8. Tables

Table 5.1: Summary statistics

Sovereign exposure is a bank's holdings of EU government debt to total assets. Home bias is 1 minus the ratio of a bank's sovereign debt portfolio share allocated to foreign EU countries divided by the share of foreign EU country sovereign debt in all EU sovereign debt held by banks in the sample. Domestic is a dummy variable indicating domestic sovereign debt exposure. Sovereign CDS is the CDS spread for five-year senior sovereign debt (in basis points/10,000). Leverage is total liabilities divided by total assets. Government ownership is the share of domestic government ownership of a bank. Corporate governance is an overall corporate governance index. Board is a corporate governance index based on board attributes. Audit is a corporate governance index based on auditing attributes. Takeover is a corporate governance index based on antitakeover attributes. Competition and ownership is a corporate governance index based on compensation and ownership attributes. Tobin's q is computed as market value of equity plus book value of liabilities divided by book value of assets. Assets is the logarithm of total assets. Deposits to liabilities is total deposits divided by total liabilities. Return on equity is operating income divided by total equity. Income diversity is 1-Abs((Net interest income - (Net noninterest income))/Total operating income). Asset diversity is 1-Abs((Net loans - Total securities)/(Net loans + Total securities)). Asset growth is the quarterly rate of change of total assets. Operating income growth is the growth rate of operating income.

	Observations	Mean	Std. Dev.	Min	Max
Sovereign exposure	9044	0.003	0.015	-0.034	0.321
Home bias	253	0.613	0.393	-3.187	1.064
Domestic	9044	0.036	0.186	0	1
Sovereign CDS	253	0.0663	0.259	0.00108	1.49
Leverage	253	0.942	0.0264	0.848	1.033
Government ownership	241	0.0538	0.149	0	0.828
Corporate governance	183	24.66	2.688	20	31
Board	183	12.8	2.085	8	17
Audit	183	1.71	0.755	0	3
Takeover	183	3.967	0.479	2	5
Competition and ownership	183	6.175	1.372	4	9
Tobin's q	253	0.984	0.0329	0.928	1.195
Assets	191	11.97	1.354	8.556	14.59
Deposits to liabilities	191	0.498	0.155	0.189	0.927
Return on equity	191	0.111	0.0947	-0.565	0.569
Income diversity	191	0.697	0.204	0.00527	0.998
Asset diversity	191	0.56	0.216	0.144	0.996
Asset growth	191	-0.00249	0.0677	-0.144	0.731
Operating income growth	191	0.0567	0.253	-0.457	2.143

Table 5.2: Correlation matrix

Tobin's q is computed as market value of equity plus book value of liabilities divided by book value of assets. Home bias is 1 minus the ratio of a bank's sovereign debt portfolio share allocated to foreign EU countries divided by the share of foreign EU country sovereign debt in all EU sovereign debt held by banks in the sample. Leverage is total liabilities divided by total assets. Sovereign CDS is the CDS spread for five-year senior sovereign debt (in basis points/10,000). Corporate governance is an overall corporate governance index. Board is a corporate governance index based on board attributes. Audit is a corporate governance index based on auditing attributes. Takeover is a corporate governance index based on antitakeover attributes. Competition and ownership is a corporate governance index based on compensation and ownership attributes. Government ownership is the share of domestic government ownership of a bank. Deposits to liabilities is total deposits divided by total liabilities. Assets is the logarithm of total assets. Income diversity is 1-Abs((Net interest income - (Net noninterest income))/Total operating income). Asset diversity is 1-Abs((Net loans - Total securities)/(Net loans +Total securities)). Return on equity is operating income divided by total equity. Asset growth is the quarterly rate of change of total assets. Operating income growth is the growth rate of operating income. *, ** and *** denote significance at 10%, 5%, and 1%.

	Tobin's q	Home Bias	Leverage	Sovereign CDS	Corporate governance	Government ownership	Deposits/ liabilities	Assets	Income diversity	Asset diversity	ROE	Asset growth	Operative income growth
Tobin's q	1												
Home Bias	0.0508	1											
Leverage	0.00372	-0.228***	1										
Sovereign CDS	0.0885	0.134*	0.128*	1									
Corporate governance	0.299***	-0.109	0.116	0.0800	1								
Government ownership	0.254***	0.0612	-0.0493	-0.0566	-0.0973	1							
Deposits/liabilities	0.172**	0.271***	-0.582***	0.126	0.0109	0.202**	1						
Assets	-0.0765	-0.357***	0.346***	-0.167**	0.282***	-0.150*	-0.576***	1					
Income diversity	-0.0411	-0.156*	0.139*	-0.230***	-0.0768	-0.0959	-0.341***	0.251***	1				
Asset diversity	-0.0106	-0.214**	0.277***	-0.153*	0.173*	0.0964	-0.368***	0.407***	0.167*	1			
ROE	-0.0527	0.0265	-0.136*	-0.365***	-0.0748	0.0244	0.144*	-0.0803	0.0404	-0.0222	1		
Asset growth	0.0309	-0.0364	-0.116	0.102	0.0462	-0.0947	0.00631	-0.0753	0.0112	-0.0663	-0.0377	1	
Operative income growth	0.0167	-0.0355	0.194**	0.114	-0.0449	-0.00445	-0.133	0.106	0.181**	0.169*	-0.0719	0.0462	1

Table 5.3: Determinants of bank exposure to sovereign debt

The dependent variable is a bank's exposure to the sovereign debt of an EU country divided by total assets. Domestic is a dummy variable indicating domestic sovereign debt exposure. *, ** and *** denote significance at 10%, 5%, and 1%.

	(1)	(2)	(3)
Domestic	0.0592***	0.0592***	0.0592***
	(9.41)	(9.37)	(9.28)
Observations	9044	9044	9044
Adjusted R^2	0.522	0.519	0.510
Bank effects	Yes	Yes	
Time effects	Yes		
Country*time effects		Yes	
Bank*time effects			Yes
Level of clustering	Bank	Bank	Bank

Table 5.4: Determinants of bank exposure to sovereign debt

The dependent variable is a bank's exposure to the sovereign debt of an EU country divided by total assets. Domestic is a dummy variable indicating domestic sovereign debt exposure. Sovereign CDS is the CDS spread for five-year senior sovereign debt (in basis points/10,000). Leverage is total liabilities divided by total assets. *, ** and *** denote significance at 10%, 5%, and 1%.

	(1)	(2)	(3)	(4)	(5)	(6)
Domestic	0.0583***	0.0583***	0.322	0.322	0.0584***	0.0584***
	(8.95)	(8.87)	(1.33)	(1.32)	(8.95)	(8.86)
Domestic * Sovereign CDS	0.0159	0.0159	-0.300*	-0.301*	-0.0986**	-0.0993**
	(1.41)	(1.39)	(-1.73)	(-1.71)	(-2.09)	(-2.07)
Domestic * Leverage			-0.279	-0.279		
			(-1.08)	(-1.07)		
Domestic * Leverage *			0.331*	0.332*	0.119**	0.120**
Sovereign CDS			(1.78)	(1.77)	(2.45)	(2.43)
Leverage			0.0140		0.00623	
			(1.22)		(0.81)	
Constant	-0.00118***	-0.000777***	-0.0145	-0.000661**	-0.00714	-0.000779***
	(-4.97)	(-3.32)	(-1.33)	(-2.27)	(-0.97)	(-3.32)
Observations	9044	9044	9044	9044	9044	9044
Adjusted R^2	0.521	0.512	0.527	0.519	0.521	0.512
Bank effects	Yes		Yes		Yes	
Country*time effects	Yes		Yes		Yes	
Bank*time effects		Yes		Yes		Yes
Level of clustering	Bank	Bank	Bank	Bank	Bank	Bank

Table 5.5: Government ownership and bank exposure to sovereign debt

The dependent variable is a bank's exposure to the sovereign debt of an EU country divided by total assets. Domestic is a dummy variable indicating domestic sovereign debt exposure. Sovereign CDS is the CDS spread for five-year senior sovereign debt (in basis points/10,000). Government ownership is the share of domestic government ownership of a bank. *, ** and *** denote significance at 10%, 5%, and 1%.

	(1)	(2)	(3)	(4)
Domestic	0.0515***	0.0515***	0.0518***	0.0518***
	(8.51)	(8.43)	(8.84)	(8.76)
Domestic * Sovereign CDS	0.0281**	0.0281**	0.0239*	0.0239*
	(2.09)	(2.07)	(1.91)	(1.89)
Domestic * Government ownership	0.0497	0.0497	-0.0338	-0.0343
	(0.97)	(0.96)	(-1.11)	(-1.12)
Domestic * Sovereign CDS * Government ownership			4.701***	4.728***
			(4.33)	(4.31)
Observations	8232	8232	8232	8232
Adjusted R^2	0.535	0.527	0.618	0.613
Bank effects	Yes		Yes	
Country*time effects	Yes		Yes	
Bank*time effects		Yes		Yes
Level of clustering	Bank	Bank	Bank	Bank

Table 5.6: Corporate governance and bank exposure to sovereign debt

The dependent variable is a bank's exposure to the sovereign debt of an EU country divided by total assets. Domestic is a dummy variable indicating domestic sovereign debt exposure. Sovereign CDS is the CDS spread for five-year senior sovereign debt (in basis points/10,000). Corporate governance is an overall corporate governance index. *, ** and *** denote significance at 10%, 5%, and 1%.

	(1)	(2)	(3)	(4)
Domestic	0.128*	0.128*	0.150**	0.150**
	(1.92)	(1.90)	(2.22)	(2.20)
Domestic * Sovereign CDS	0.0305*	0.0305*	-0.170***	-0.172***
	(1.77)	(1.75)	(-3.06)	(-3.03)
Domestic * Corporate governance	-0.00328	-0.00328	-0.00413	-0.00414
	(-1.21)	(-1.20)	(-1.52)	(-1.51)
Domestic * Sovereign CDS * Corporate governance			0.00776***	0.00782***
			(3.61)	(3.57)
Observations	5152	5152	5152	5152
Adjusted R^2	0.499	0.491	0.509	0.501
Bank effects	Yes		Yes	
Country*time effects	Yes		Yes	
Bank*time effects		Yes		Yes
Level of clustering	Bank	Bank	Bank	Bank

Table 5.7: Corporate governance subindices and bank exposure to sovereign debt

The dependent variable is a bank's exposure to the sovereign debt of an EU country divided by total assets. Domestic is a dummy variable indicating domestic sovereign debt exposure. Sovereign CDS is the CDS spread for five-year senior sovereign debt (in basis points/10,000). Board is a corporate governance index based on board attributes. Audit is a corporate governance index based on auditing attributes. Takeover is a corporate governance index based on antitakeover attributes. Competition and ownership is a corporate governance index based on compensation and ownership attributes. *, ** and *** denote significance at 10%, 5%, and 1%.

	(1)	(2)	(3)	(4)	(5)
Domestic	0.143***	0.0473***	0.00517	0.0527	0.139*
	(3.44)	(2.89)	(0.13)	(1.65)	(1.73)
Domestic * Sovereign CDS	-0.152***	-0.0336	-2.165**	-0.0536	-0.103
	(-4.47)	(-0.99)	(-2.42)	(-0.86)	(-0.05)
Domestic * Board	-0.00745**				-0.00830***
	(-2.38)				(-2.74)
Domestic * Sovereign CDS * Board	0.0146***				0.0735*
	(5.57)				(1.99)
Domestic * Audit		0.000461			0.00612
		(0.05)			(0.61)
Domestic * Sovereign CDS * Audit		0.0263*			0.220
		(2.02)			(1.00)
Domestic * Takeover			0.0106		-0.00228
			(1.02)		(-0.16)
Domestic * Sovereign CDS * Takeover			0.548**		0.159
			(2.45)		(0.35)
Domestic * Compensation and ownership				-0.000770	0.00177
				(-0.15)	(0.40)
Domestic * Sovereign CDS				0.0107	-0.249
* Compensation and ownership				(1.40)	(-1.44)
Observations	5152	5152	5152	5152	5152
Adjusted R^2	0.524	0.478	0.494	0.477	0.550
Bank*time	Yes	Yes	Yes	Yes	Yes
Level of clustering	Bank	Bank	Bank	Bank	Bank

Table 5.8: Bank valuation and the sovereign debt home bias

The dependent variable is Tobin's q computed as market value of equity plus book value of liabilities divided by book value of assets. Home bias is 1 minus the ratio of a bank's sovereign debt portfolio share allocated to foreign EU countries divided by the share of foreign EU country sovereign debt in all EU sovereign debt held by banks in the sample. Sovereign CDS is the CDS spread for five-year senior sovereign debt (in basis points/10,000). Leverage is total liabilities divided by total assets. Assets is the logarithm of total assets. Deposits to liabilities is Deposits to liabilities is total deposits divided by total liabilities. Return on equity is operating income divided by total equity. Income diversity is 1-Abs((Net interest income - (Net noninterest income))/Total operating income). Asset diversity is 1-Abs((Net loans - Total securities)/(Net loans +Total securities)). Asset growth is the quarterly rate of change of total assets. Operating income growth is the growth rate of operating income. Regressions with portfolio shares additionally include the bank's sovereign exposure to each country as a percentage of the bank's total sovereign debt portfolio. *, ** and *** denote significance at 10%, 5%, and 1%.

	Portfolio shares not included								Portfolio shares included			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Home Bias	0.00687**	0.00570***	0.00721**	0.00643***	0.175	0.538	0.00752***	0.00673***	-0.333	-0.181	0.00906***	0.00863
	(2.55)	(6.28)	(2.49)	(7.54)	(0.33)	(1.19)	(6.84)	(6.12)	(-0.81)	(-0.36)	(3.50)	(1.49)
Home Bias * Sovereign			-0.0587	-0.143***	-1.703***	-1.887***	-1.577***	-1.518***	-1.183***	-1.000***	-1.427***	-1.130***
CDS			(-1.38)	(-4.12)	(-4.47)	(-6.43)	(-10.49)	(-14.16)	(-4.45)	(-2.95)	(-12.52)	(-6.34)
Home Bias * Leverage					-0.175	-0.558			0.359	0.199		
					(-0.32)	(-1.17)			(0.83)	(0.38)		
Home Bias * Sovereign					1.638***	1.839***	1.502***	1.439***	1.162***	1.100***	1.424***	1.238***
CDS * Leverage					(4.08)	(5.85)	(11.21)	(14.46)	(4.06)	(3.13)	(15.52)	(6.78)
Assets		-0.0294**		-0.0249***		-0.0219**		-0.0255***		-0.00646		-0.00507
		(-2.16)		(-3.24)		(-2.62)		(-3.10)		(-0.19)		(-0.16)
Leverage		0.717**		0.929***	1.095*	1.242***	0.969***	0.900**	0.550	0.567	0.852***	0.721***
		(2.77)		(4.34)	(2.08)	(2.97)	(4.54)	(2.80)	(1.45)	(1.30)	(5.56)	(3.67)
Leverage * Sovereign					-1.273***	-1.366***	-1.172***	-1.130***	-0.747***	-0.535*	-0.967***	-0.638***
CDS					(-3.34)	(-4.67)	(-6.55)	(-6.55)	(-2.94)	(-1.92)	(-9.35)	(-3.44)
Deposits/liabilities		-0.0650		-0.0493		-0.0457		-0.0500		-0.0360		-0.0368

		(-0.88)		(-0.75)		(-0.66)		(-0.76)		(-0.73)		(-0.72)
ROE		0.00480		0.0128		0.0122***		0.00911*		0.00585		0.00670
		(0.94)		(1.59)		(3.19)		(2.04)		(1.09)		(1.57)
Income diversity		-0.00831		0.00106		0.000386		-0.000312		-0.0110		-0.0107
		(-1.13)		(0.14)		(0.06)		(-0.05)		(-1.30)		(-1.24)
Asset diversity		-0.0215		-0.0274		-0.0277		-0.0185		0.00340		-0.000874
		(-0.81)		(-0.96)		(-0.88)		(-0.65)		(0.07)		(-0.02)
Asset growth		-0.00256		-0.00565		-0.0134		-0.00721		0.00776		0.00485
		(-0.25)		(-0.53)		(-1.18)		(-0.71)		(0.12)		(0.08)
Operative income growth		0.00481		0.00516		0.00277		0.00265		0.000874		0.00120
		(0.59)		(0.64)		(0.74)		(0.66)		(0.21)		(0.36)
Observations	253	191	253	191	253	191	253	191	253	191	253	191
Adjusted R^2	0.926	0.950	0.927	0.962	0.968	0.969	0.968	0.968	0.980	0.983	0.980	0.984
Bank effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country*time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Level of clustering	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country

Table 5.9: Bank valuation and the sovereign debt home bias over time

This table reports separate valuation regressions for each of the six stress tests dates in our sample. The specification corresponds to regression 5 in Table 5.8. The dependent variable is Tobin's q computed as the market value of equity plus book value of liabilities divided by book value of assets. Home bias is 1 minus the ratio of a bank's sovereign debt portfolio share allocated to foreign EU countries divided by the share of foreign EU country sovereign debt in all EU sovereign debt held by banks in the sample. Sovereign CDS is the CDS spread for five-year senior sovereign debt (in basis points/10,000). Leverage is total liabilities divided by total assets. Assets is the logarithm of total assets. Deposits to liabilities is Deposits to liabilities is total deposits divided by total liabilities. Return on equity is operating income divided by total equity. Income diversity is 1-Abs((Net interest income - (Net noninterest income))/Total operating income). Asset diversity is 1-Abs((Net loans - Total securities)/(Net loans +Total securities)). Asset growth is the quarterly rate of change of total assets. Operating income growth is the growth rate of operating income. *, ** and *** denote significance at 10%, 5%, and 1%.

	(1) 31/03/10	(2) 31/12/10	(3) 31/12/11	(4) 30/06/12	(5) 31/12/12	(6) 30/06/13
Home Bias	2.147	2.208	2.710*	3.210**	1.874	2.338*
	(1.24)	(1.34)	(2.08)	(2.65)	(1.71)	(2.12)
Home Bias * Sovereign	-22.64	-19.57	-18.16	-31.61**	-0.989**	-1.065***
CDS	(-0.44)	(-1.31)	(-1.53)	(-2.23)	(-2.27)	(-3.41)
Home Bias * Leverage	-2.254	-2.344	-2.834*	-3.354**	-1.990	-2.483**
	(-1.24)	(-1.34)	(-2.06)	(-2.64)	(-1.72)	(-2.13)
Home Bias * Sovereign	23.47	21.72	18.62	32.14**	1.095**	0.958***
CDS * Leverage	(0.43)	(1.38)	(1.50)	(2.19)	(2.31)	(3.04)
Leverage * Sovereign	-0.189	-1.122	0.0550	0.426*	-0.0654**	0.180***
CDS	(-0.10)	(-1.66)	(0.52)	(2.01)	(-2.22)	(12.04)
Leverage	1.028*	1.095*	1.700***	1.775***	1.523**	1.976**
	(2.02)	(1.97)	(3.58)	(3.55)	(2.37)	(2.82)
Constant	0.00909	-0.0413	-0.644	-0.714	-0.455	-0.883
	(0.02)	(-0.08)	(-1.43)	(-1.51)	(-0.75)	(-1.34)
Observations	44	49	38	39	42	41
Adjusted R^2	0.163	0.165	0.330	0.445	0.223	0.145
Level of clustering	Country	Country	Country	Country	Country	Country

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