Banking, Business Cycles and Corporate Bond Markets in the Context of Financial Stability and European Integration

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Summary

This thesis combines five chapters, all of which have been motivated by the exciting and intense policy discussions that have been dominating the political and economic landscape in recent years. It covers European bank regulation and its effects on financial stability and economic welfare, the implications of international capital flows through the banking system and bank short-term wholesale funding, contagious spillovers between banks and sovereigns, the tensions in the euro zone due to diverging developments of unit labor costs and corporate bond issues before and during the financial crisis. European integration – in its many forms – is therefore the unifying element of all papers. Nevertheless, most findings are universally applicable and relevant also for a broader geographic area.

Chapter 1 is dedicated to discussing selected recent economic issues and to providing a comprehensive overview of the current state of the literature in these areas. It also presents a graphical overview of the mechanisms and topics in this thesis and embeds the subsequent chapters into a broader and integrated perspective. **Chapter 2** then attends to the issues related to cross-border capital flows channelled through the banking system, roll-over risk of short-term bank funding and the regulatory challenges imposed by harmful private incentives, risk-shifting towards depositors as well as other frictions and inefficiencies. These topics have not been studied in interaction before. The model explains the need for regulation, analyzes two concrete policy options and their implications and addresses the international dimension of the topic in the fiscally fragmented euro area. The role of the banking sector should additionally be seen in the context of **chapter 3**, which investigates the emergence of underlying imbalances in the real economy due to undisciplined and uncoordinated wage-setting across the euro zone. After all, these imbalances were magnified by the banking system and its misguided regulation respectively. The paper is the first academic contribution to empirically highlight the negative consequences of diverging unit labor costs on business cycle synchronization and thus bears important policy implications. **Chapter 4** proceeds along the European context as it explores the bank-sovereign nexus which stood at the heart of the recent banking and sovereign debt crisis. It works out the precise mechanisms of mutual contagion between banks and sovereigns and discusses them in the light of deposit insurance, equity requirements, bank asset allocation

between bonds and loans and other economic indicators. Finally, **chapter 5** empirically investigates European corporate bond issues before and during the financial crisis. It uses a self-compiled dataset, which reflects the rich interplay between a company's location, its balance sheet characteristics, as well as macroeconomic indicators, and highlights important, heterogeneous responses to the crisis with respect to the number and volume of issues as well as bond maturity which depend on a firm's location.

All papers share their immanent policy relevance and are motivated by the aspiration to investigate and discuss important economic and financial topics with novel empirical and theoretical approaches.

Zusammenfassung

Diese Dissertation besteht aus fünf Kapiteln, die alle von den spannenden und intensiven Diskussionen inspiriert sind, welche die politische und ökonomische Agenda der letzten Jahre so eindrücklich geprägt haben. Sie umspannt das Themengebiet europäische Bankenregulierung und deren Effekte auf Finanzstabilität und ökonomische Wohlfahrt, die Implikationen von internationalen Kapitalflüssen durch das Bankensystem und die kurzfristige Refinanzierung von Banken über Wholesale Märkte, die Ansteckungseffekte zwischen Banken und Staaten, die Spannungen in der Eurozone aufgrund von divergierenden Entwicklungen der Lohnstückkosten, sowie das Anleihenausgabeverhalten von Firmen vor und während der Finanzkrise. Europäische Integration – in ihren vielen Facetten – ist deshalb das verbindende Element aller Kapitel. Nichtsdestotrotz sind die meisten Erkenntnisse universell anwendbar und auch für ein breiteres geographisches Gebiet relevant.

Kapitel 1 widmet sich der Diskussion ausgewählter ökonomischer Anliegen der vergangenen Jahre und bietet einen umfangreichen Überblick des derzeitigen Stands der Literatur auf diesen Gebieten. Es präsentiert auch eine grafische Übersicht der Mechanismen und Themen, die in dieser Dissertation behandelt werden, und bettet die nachfolgenden Kapitel in eine breitere und ganzheitliche Perspektive ein. **Kapitel 2** beschäftigt sich dann mit grenzüberschreitenden Kapitalflüssen durch das Bankensystem, dem Roll-over Risiko von kurzfristigen Bankverbindlichkeiten und den regulatorischen Herausforderungen aufgrund von schädlichen privaten Anreizen, Risikotransfers von Banken zu Sparern sowie anderen Friktionen und Ineffizienzen. Diese Themen wurden bisher noch nie in ihrer Interaktion studiert. Das Modell erklärt die Notwendigkeit von Regulierung, analysiert zwei konkrete Eingriffsmöglichkeiten sowie deren Implikationen und adressiert die internationale Dimension des Themas in der fiskalisch fragmentierten Eurozone. Die Rolle des Bankensektors sollte zusätzlich im Kontext von **Kapitel 3** betrachtet werden, welches die Entstehung der zugrunde liegenden Ungleichgewichte in der Realwirtschaft aufgrund von undisziplinierter und unkoordinierter Lohnsetzung innerhalb der Eurozone untersucht. Diese wurden nämlich durch die übermässige Elastizität des Bankensystems bzw. dessen falsche Regulierung verstärkt. Das Papier ist der erste akademische Beitrag, der die negativen Konsequenzen von divergierenden Lohnstückkosten auf die Synchronisation von Konjunkturzyklen empirisch aufzeigt und birgt daher bedeutende Implikationen für die Wirtschaftspolitik. **Kapitel 4** fährt entlang dieses europäischen Kontexts fort und erforscht den Nexus zwischen Banken und Staaten, welcher im Zentrum der jüngsten Banken- und Staatsschuldenkrise steht. Es arbeitet die präzisen Ansteckungsmechanismen zwischen Banken und Staaten heraus und diskutiert diese im Lichte von Einlagensicherung, Eigenkapitalanforderungen, der Asset-Allokation von Banken zwischen Anleihen und Krediten sowie anderen ökonomischen Indikatoren. Schliesslich untersucht **Kapitel 5** empirisch die Ausgabe von europäischen Firmenanleihen vor und während der Finanzkrise. Es verwendet einen selbsterstellten Datensatz, welcher das reichhaltige Zusammenspiel zwischen dem Standort einer Firma, deren Bilanzkennzahlen sowie makroökonomischen Indikatoren reflektiert. Das Kapitel streicht wichtige, heterogene Reaktionen auf die Krise im Hinblick auf Anzahl, Volumen sowie Laufzeiten von ausgegebenen Anleihen hervor, welche vom Standort der Firma abhängen.

Alle Kapitel teilen sich ihre immanente Relevanz für die Wirtschaftspolitik und sind vom Anspruch motiviert, bedeutende ökonomische und finanzielle Themen mit neuartigen empirischen und theoretischen Herangehensweisen zu untersuchen.

Chapter 1

Introduction

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2 The papers in this thesis have been presented at the Meeting of the Eastern Finance Association in Pittsburgh (USA), the Meeting of the Royal Economic Society in Manchester (UK), the Conference of the Western Economic Association in Denver (USA), two Joint Accounting/Finance Seminars at Stanford Graduate School of Business (USA), the Economics Seminar at the University of Innsbruck (AUT), the Swiss Meeting of Young Economists in Bern (CH), the Lindau Meeting for Nobel Prize Laureates in Economics (DE), the Academic Conference of the Campus for Finance at the WHU Otto-Beisheim-School in Koblenz/Vallendar (DE), two PhD seminars at the University of St. Gallen (CH), Internal Seminars at chair of Prof. Keuschnigg, the Brown Bag seminar at the Swiss Institute for Banking and Finance, the PiF seminar at the School of Finance, and the Brown Bag seminar at the department of Economics at the University of St. Gallen (CH).

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1.1 Introduction

The introduction of the Euro in 1999[4] marked the beginning of a new era for Europe and the member countries of the Economic and Monetary Union (EMU) in particular. Individual national banks delegated the control over their policy interest rates to the European Central Bank (ECB) and could no longer influence their countries' nominal exchange rates afterwards. Asset booms in Europe's periphery subsequently offered attractive investment opportunities in the early 2000s. These were further fueled by relatively low real interest rates resulting from high cost-push inflation caused by generous wage settlements. Huge amounts of capital were flowing into Portugal, Ireland, Italy, Greece, and Spain (GIIPS). In fact, during that period, Europe accounted for half of the growth in global capital flows, which had reached a record level of 11.8 trillion in 2007, up from 0.5 trillion in 1980 (McKinsey Global Institute, 2013). These flows were often short-term and channelled through the banking system. Cross-border assets and liabilities of European banks increased five-fold in the decade before the crisis. Banks benefited tremendously and their profits reached ever new heights. Regulation has often been too lenient in this context or simply incomplete and misdirected. The fact that major players in Europe's core economies were hugely capitalizing on the flourishing but highly indebted GIIPS has surely been conducive to this tolerant attitude. Hence, the local booms were initially regarded as a natural catching-up process resulting from reduced frictions and increased economic efficiency due to the EMU. Recent events, however, painfully demonstrated that some major threats and imbalances had been carelessly ignored: As the lack of competitiveness of Europe's periphery and the problems in the banking sector became apparent, short-term capital was flowing back to Europe's core at a massive speed. Banks' funding sources, which had often been funded on short-term wholesale markets, evaporated suddenly. Their liquidity buffers and capital positions, however, were weak, which meant that they were extremely vulnerable to asset price movements and funding instabilities. When governments had to step in to bail them out, the negative consequences of the nexus between banks and over-indebted sovereigns, the build-up of which had been reinforced during the run-up to the crisis by zero regulatory risk weights for sovereign bonds and other misdirected regulations, gained full momentum. As banks cut back their lending to the corporate sector, firms tapped the bond markets instead. These, however, are not equally well developed in Europe as they are in the US and even show considerable variation within Europe. Cross-country heterogeneities of that kind impeded a dynamic economic recovery in some regions and gave rise to national interests which complicated political reforms and timely interventions. The interplay of these effects is fascinating, complex and highly relevant. The following chapters ambitiously aim at deepening their understanding and at deriving practicable

[4] Greece (2001), Slovenia (2007), Cyprus/Malta (2008), Slovakia (2009), Estonia (2011), Lithuania (2014)

policy suggestions.

Section 1.2 of this first chapter is dedicated to discussing these issues and the related academic literature in more detail. It furthermore provides a graphical overview of key mechanisms in figure 1.1 and thereby embeds the subsequent chapters of this thesis into a broader and integrated perspective. Section 1.3 then provides a short summary of chapters 2, 3, 4 and 5 as well as policy recommendations that may be derived from them. Section 1.5 then discusses selected implementation issues before section 1.6 eventually concludes with a short outlook.

1.2 Key issues and related literature

1.2.1 Diverging unit labor costs, competitiveness and imbalances

Unit labor costs in peripheral countries had been rising excessively fast. While the Schröder government's 'Agenda 2010' depressed Germany's labor costs at the start of the millennium, the euphoria into the GIIPS incentivized local institutions to ever-higher wage settlements. In fact, nominal wages increased far above what would have been justified by productivity increases alone. As a consequence, households' disposable income grew. This stimulated domestic demand, which was further exaggerated by excessive government spending. The latter was the result of overly cheap funding conditions for numerous sovereigns as interest rates on government bond issues across the EMU had rapidly converged downwards after the introduction of the common currency in 1999. During that time period, debtors and creditors alike seemed to ignore the excessively different debt levels and structural deficits across EMU countries.

> *'...there was a lack of discipline, on the side of lenders as well as borrowers. This lack of discipline was to some extent due to the lack of an exchange mechanism. For a country that has its own currency, the exchange rate typically provides a disciplining mechanism. This mechanism may work because it goes against the country's pride to see the exchange rate devalued, and therefore policies that destroy the international competitiveness of important industries may come to be questioned when the loss of competitiveness affects the exchange rate. Or it may work because lenders distrust the country government's ability to finance its activities without using the printing press and therefore refuse to lend in the country's currency, a constellation which Eichengreen and Hausmann (1999) have called original sin.' (Hellwig, 2011)*

The failure of financial markets to take account of the fact that different sovereign borrowers had different fiscal capacities represented an anomaly based on which Hellwig (2011) considers the possibility that market agents may just have smartly 'gamed the system' by anticipating *ex post* bail-outs for over-indebted, troubled sovereigns. The combination of overly generous wage settlements and excessive (cheap) government spending initially created artificial booms. Rent-seeking foreign capital was therefore flowing into the periphery and unit labor costs were pushed up even further. These investments in the GIIPS were considered a blessing at first since capital was flowing to places where it could supposedly be most productive. The GIIPS' level of competitiveness, however, was steadily deteriorating and they started to amass considerable current account deficits. The onset of the crisis abruptly revealed the full magnitude of these imbalances.

> *'I believe that the single most important problem is the divergent trend of unit labor costs in Europe'. (Keuschnigg, 2012)*

GIIPS and the euro zone as a whole were suddenly faced with dangerous differences in competitiveness as well as desolate banking sectors, unbearable public debt and a negative feedback look between the financial sector and the sovereigns. In the 80s or the 90s countries such as Italy would just have weakened their currency in such a situation. But the exchange rate was no longer in their hands and sticky wages as well as political rigidities inhibited rapid internal devaluations and structural reforms. Hence, when the optimism vanished, it made way for panic and substantial doubts about the periphery's economic viability.

1.2.2 Capital flows and the banking system

Additionally, by 2007/2008, the immense **capital flows** towards the GIIPS had reached a level at which any minor distortion would become a major threat. When the crisis erupted they rapidly turned into unprecedented outflows to Europe's core countries or 'safe havens' outside the euro area. Euro zone banks, for instance, reduced their cross-border lending within Europe by 2.8 trillion US dollars between the fourth quarter of 2007 and the end of 2013. The **short-term** nature of these funds and the lack of sufficient regulatory attention were particularly conducive to this level of fragility:

> *'I am not concerned about these capital flows per se. As a consequence of monetary union, some such capital flows were to be expected - and were fully intended ... However, governance mechanisms for these capital flows were insufficient. Capital flows to banks in Ireland and Spain took too little account of the dangers inherent in the Wicksellian dynamics of real interest rates, investment and housing price appreciation generating a bubble.' (Hellwig, 2011)*

Against this background Borio and Disyatat (2012) prominently claim that:

> *'merely looking at current account deficits and net capital flows ('savings view') is an insufficient explanation for the crisis ... the main contributing factor to the financial crisis was the 'excess elasticity' of the international monetary and financial system: the*

monetary and financial regimes in place failed to restrain the build-up of unsustainable credit and asset price booms ('financial imbalances').' (Borio and Disyatat, 2012)

Along related lines, Shin (2012) convincingly argues that the 'global savings glut' narrative, which had been considered the single most relevant indicator of economic imbalances for long, should be complemented by what he calls the 'global banking glut'. The latter describes the rise in cross-border lending of banks and the **excess elasticity of the banking system** as a whole. Shin's narrative is particularly interesting against the background of European labor markets as it suggests that the pro-cyclical framework of the banking system may have multiplied existing divergences of unit labor costs as illustrated at the bottom left of figure 1.1: Large banks especially had been able to misuse internal risk models in order to depress the risk weights applied to their positions when asset markets were booming. Consequently, bank balance sheets were growing at rates far above GDP trend while the amount of bank equity remained rather stable on aggregate. This in turn allowed firms in the GIIPS to finance generous wage settlements and permitted banks to significantly increase their leverage ratios, defined as book value of total assets divided by the book value of equity, while keeping regulatory ratios, defined as the ratio of tier 1 capital to risk-weighted assets, fixed (Acharya et al., 2014; Adrian and Shin, 2010; Hahm et al., 2012; Shin, 2012). The rise of the banks' average leverage ratio until 2008 and the considerable variation across countries is shown in figure 1.2 in the appendix of this section.

As deposit growth could not keep pace with this expansion, new investments were financed by short-term debt instead; often provided by wholesale money markets funds domiciled in France, Ireland, Luxembourg and the US. After the crisis hit, short-term financiers and banks withdrew their money immediately. The 'dark side' of short-term debt became apparent (Huang and Ratnovski, 2011). Banks in the periphery, which had been the main recipients of these funds in the run-up to the crisis, were subsequently forced to deleverage substantially; often so by liquidating assets at excessively low prices (Brunnermeier and Pedersen, 2009; Brunnermeier et al., 2009; Shleifer and Vishny, 1992). Due to considerable losses on these positions, withdrawals from short-term financiers and the sudden awareness of their vulnerability banks found themselves caught in a deadly downward spiral and cut back their lending to the 'real sector'. In fact, total assets of the euro area banking system have declined by almost 12 percent since 2008; the number of credit institutions has fallen by 9 percent, or around 600 institutions in net terms (ECB, 2014a). These downward adjustments were particularly disastrous in Europe, where banks had been operating at marginal equity cushions and liquidity provisions, and which had become severely 'over-banked' (Acharya et al., 2014).[5]

[5] Between 1950 and 2008, the bank credit-to-GDP ratio had grown from about 25 percent to above 100 percent as compared to 50 percent in the US according to Schularick and Taylor (2012), who pin down credit growth as a key predictor of financial crises. These findings are supported by Reinhart

1.2.3 Bank regulation

1.2.3.1 Frictions, implicit subsidies, and equity regulation

As a logical consequence, **bank regulation** has been among the most prominent and productive research areas in recent years. Anat Admati and Paul Pfleiderer – who I was fortunate to visit for one year at Stanford – with co-authors, are among the key proponents for tighter bank **equity requirements** and a more welfare oriented approach towards regulation. They explain their reasoning in numerous influential contributions (Admati et al., 2011, 2012, 2013; Admati and Pfleiderer, 2010; Admati and Hellwig, 2013b,c). In Admati and Pfleiderer (2010), for instance, the authors state that:

> *'Incentives for 'risk shifting' constitute one of the main agency problems associated with debt financing ... Intuitively, higher riskiness allows the equity holders to realize benefits on the upside, while debt holders bear the costs on the downside. This problem is particularly severe if the debt is insured through either deposit insurance or implicit government guarantees. In this case it is the government or the insurer who bears the downside risk.' (Admati and Pfleiderer, 2010)*

The costs of excessively low bank equity cushions are therefore ultimately imposed on society while the costs of higher equity requirements would be entirely private to the banks and due only to their lost ability to shift some of their costs to others (Admati, 2014). In the authors' view, banks are still 'too-big-to-fail' and benefit from implicit government guarantees in inefficient ways. The list of disadvantages from sustaining such an under-capitalized banking system is long: Debt overhang may prevent investments into worthy projects (Admati et al., 2012; Myers, 1977; Philippon, 2010); agency conflicts between borrowers and shareholders may exacerbate; banks become prone to suboptimal cycles of boom and bust; bankruptcy costs are thus incurred more frequently and are ultimately burdened on the taxpayer.

These problems are particularly severe in Europe, where the largest 20 institutions alone were responsible for the near-doubling in the size of the EU banking system (relative to GDP) between 1996 and 2012, and where regulators have been overly hesitant to let banks fail: Acharya et al. (2014), for instance, claim that *'European governments have granted more support to distressed banks, especially large ones, than the US, implying a more serious moral hazard problem ... far fewer EU banks have failed since 2008 compared with the number of banks that have been resolved by the FDIC in the US;'* and also Christine Lagarde, Managing Director of the International Monetary Fund, makes a

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and Rogoff (2011), who show that larger banking sectors are associated with deeper recessions, as well as Alessi and Detken (2009). Interestingly, credit growth after 1995 had been most pronounced in Portugal, Spain, Ireland, and Cyprus.

convincing case for that observation when she states that:

> *'The implicit subsidy for mega-banks is still going strongly – amounting to about 70 billion USD in the US, and up to 300 billion USD in the euro area.' (International Monetary Fund, 2014a)*

Further interventions are thus indispensable. In fact, the banks' addiction to debt is fostered by the status quo. According to Admati et al. (2013) the high leverage of the banking system generates a 'ratchet effect' towards ever higher debt levels and ever shorter maturities, the latter of which has been described by Brunnermeier and Oehmke (2013) as a 'maturity rat race'. The authors derive that behavior from the banks' inability to commit not to harm existing creditors. Roll-over risks have therefore been constantly intensifying in the run-up to the crises.

Against these arguments the case for higher leverage almost seems obscure. Nevertheless, the 'disciplining role' of debt provided by short-term creditors has received prominent support from academics in the past (Diamond and Rajan, 2001; Calomiris and Kahn, 1991; Calomiris, 1999). The influential Squam Lake Report (French et al., 2010) (p. 69), for instance, states that *'Capital requirements are not free. The disciplining effect of short-term debt makes management more productive'.* DeAngelo and Stulz (2013) even argue recently that 'high leverage is optimal for banks' although the latter hold only risk-less assets in their model. Pfleiderer (2014) and Admati (2014) thus criticise the paper fiercely and argue that short-term debt has proven to provide the 'opposite of discipline'.

> *'... the notion that short-term debt plays a critical role in disciplining bank managers in the actual world seems to be based on chameleons: theoretical results have been taken off the bookshelf and applied to the real world without passing them through a reasonable filter.' (Pfleiderer, 2014)*

Admati and Hellwig (2013a) additionally highlight that the 'disciplining narrative' is, in fact, incompatible with the view that information-insensitive depositors and other short-term creditors contribute to liquidity provision. Assuming both at the same time – as it is done in many models – is thus a contradiction in itself. Overall, the tide seems to have turned towards tighter regulation; higher equity ratios are now commonly believed to reduce banks' vulnerability and to alleviate decisive incentive problems inherent in the banking industry without causing major welfare losses.

1.2.3.2 Short-term funding and roll-over risk

Also bank liquidity has taken center stage in the recent crisis. Brunnermeier et al. (2009), for example, write that *'solvency issues are not exogenous to liquidity. When* *there is a generalised liquidity problem, attempts to deal with it will lead to declines in asset values, creating a solvency problem, even where none existed before'*. Similarly, Tarullo (2014) states that *'In practice, the line between illiquidity and insolvency can be very blurry'*. As a consequence, a related strand of literature most recently additionally devoted increased attention to the issue of bank **liquid asset holdings** and short-term funding. Brunnermeier et al. (2009), Stein (2013), Farhi and Tirole (2012), Krishnamurthy and Vissing-Jorgensen (2013), Shin (2008), Perotti and Suarez (2011), Acharya et al. (2011b) and Diamond (2008), among others, argue that liquidity shortfalls acted as a major accelerator during the 2008 financial turmoil. In fact, it has been claimed that illiquidity may potentially endanger even healthy banks:

> *'... In the past, such instability was partly checked by reserve requirements tied to deposits ... More recently, liquidity risk has come less from deposit outflows and more from exposure to a range of lending and interbank financial arrangements. These include undrawn loan commitments, obligations to repurchase securitized assets, margin calls in the derivatives markets, and withdrawal of funds from wholesale short-term financing arrangements.' (Strahan, 2012)*

The same issue is discussed in Huang and Ratnovski (2011), who provide an illustrative model which convincingly illustrates the pitfalls of short-term funding[6] and roll-over risk. The disastrous consequences these risks may exert on individual institutes and the financial system as a whole have been showcased by the prominent failures of Northern Rock, Lehman Brothers and Bear Stearns. All three were insufficiently prepared for sudden mass withdrawals from their wholesale financiers. The French-Belgium Dexia bank, which had been primarily engaged in granting long-term loans to municipalities and which refinanced 43 percent of its balance sheet on short-term wholesale markets, was unable to roll-over the financing of its longer-term assets too as the quality of its 203 billion USD proprietary bond portfolio worsened and was eventually bailed out in 2008 (Acharya and Steffen, 2014).[7]

Bai et al. (2014), Feldman and Schmidt (2001) as well as Hahm et al. (2012) therefore bring up (non-core) short-term debt as a potential macro-prudential indicator for systemic vulnerability. In this regard, the former compute that US banks faced a liquidity shortfall of 4.35 trillion US dollars in 2007. Tirole (2011) shows that it may, in fact, be optimal for banks to 'underhoard' liquid quality assets in normal times in order to benefit from more profitable investment alternatives. From a financial stability perspective central banks may then step in as liquidity providers during distress. Yet, their role as lenders-of-last resort (LOLRs) may foster significant problems: First, the

[6] The sheer size of the shadow banking system, where many of these funds are coming from, and its negative stereotypes resulted in significant media coverage (Handelsblatt, 2012; NZZ, 2012).

[7] The exposure to sovereign debt of the GIIPS countries amounted to five to six times its book equity at that time (Acharya and Steffen, 2014).

central bank may not always be able to differentiate between illiquid and insolvent banks. This is especially true during periods of financial turmoil when asset prices are extremely volatile. Second, the fear of large scale consequences of inaction might induce it to intervene even for insolvent institutes, which are therefore kept alive inefficiently. Third, banks may anticipate this choice which fosters moral hazard. Fourth, central bank lending may facilitate exit by the uninsured depositors of a troubled bank, which raises the costs borne by remaining creditors or the deposit insurance fund.[8] As a consequence, the Basel Committee on Banking Supervision recently introduced the liquidity coverage ratio (LCR), which is to be implemented incrementally until 2018 in Europe and until 2017 in the US (Federal Reserve Board, 2014), and the net stable funding ratio (NSFR) for banks[9] and suggests similar measures for asset management companies as well:[10]

> *'Asset management companies' incentive structures ... can generate concerted behaviour and thus amplify financial market fluctuations ... redemption risk can be addressed by liquidity buffers and – in the spirit of recent amendments to US money market fund rules – by restrictions on rapid redemptions from managed funds. This could insulate asset managers from hasty swings in retail investor sentiment, thus boosting the sector's loss-absorbing capacity.' (BIS, 2015)*

1.2.4 Bank-sovereign nexus

To make things worse, euro zone banks had entered into a **dangerous liaison with their local governments**. Traditional academic contributions have largely neglected this interconnectedness for long and instead focused on one of the two players in isolation: While Romer (2001) and Calvo (1988), for instance, discuss government debt and sovereign default, Allen and Gale (2000), Rochet and Tirole (1996) and Diamond (1984) predominantly analyze the banking sector itself as well as the contagion between banks. The recent crisis then highlighted the need for a more integrated approach: Bolton and Jeanne (2011), Battistini et al. (2013) and Mody and Sandri (2012) show that banks had become their sovereign's major creditors by 2007/2008. This link proved to be particularly problematic in the EMU, where fiscal competencies and deposit insurance remained fragmented while the financial sector had become extremely

8 See Tarullo (2014) for a more detailed discussion.

9 While the former is defined as high quality liquid assets over projected net outflows within a 30-day stress period in order to guarantee the bank's stability within a short-term period – the guidelines state that *'at a minimum, the stock of unencumbered HQLA should enable the bank to survive until Day 30 of the stress scenario'* –, the latter is calculated by dividing the available amount of stable funding by the required amount of stable funding to guarantee an appropriate long-term funding structure (BIS, 2013).

10 Similarly, the world's largest asset manager BlackRock has been calling for international rules that could impose redemption fees for some kinds of funds in order to cut the chances of damaging runs during times of market panic (Financial Times, 2014).

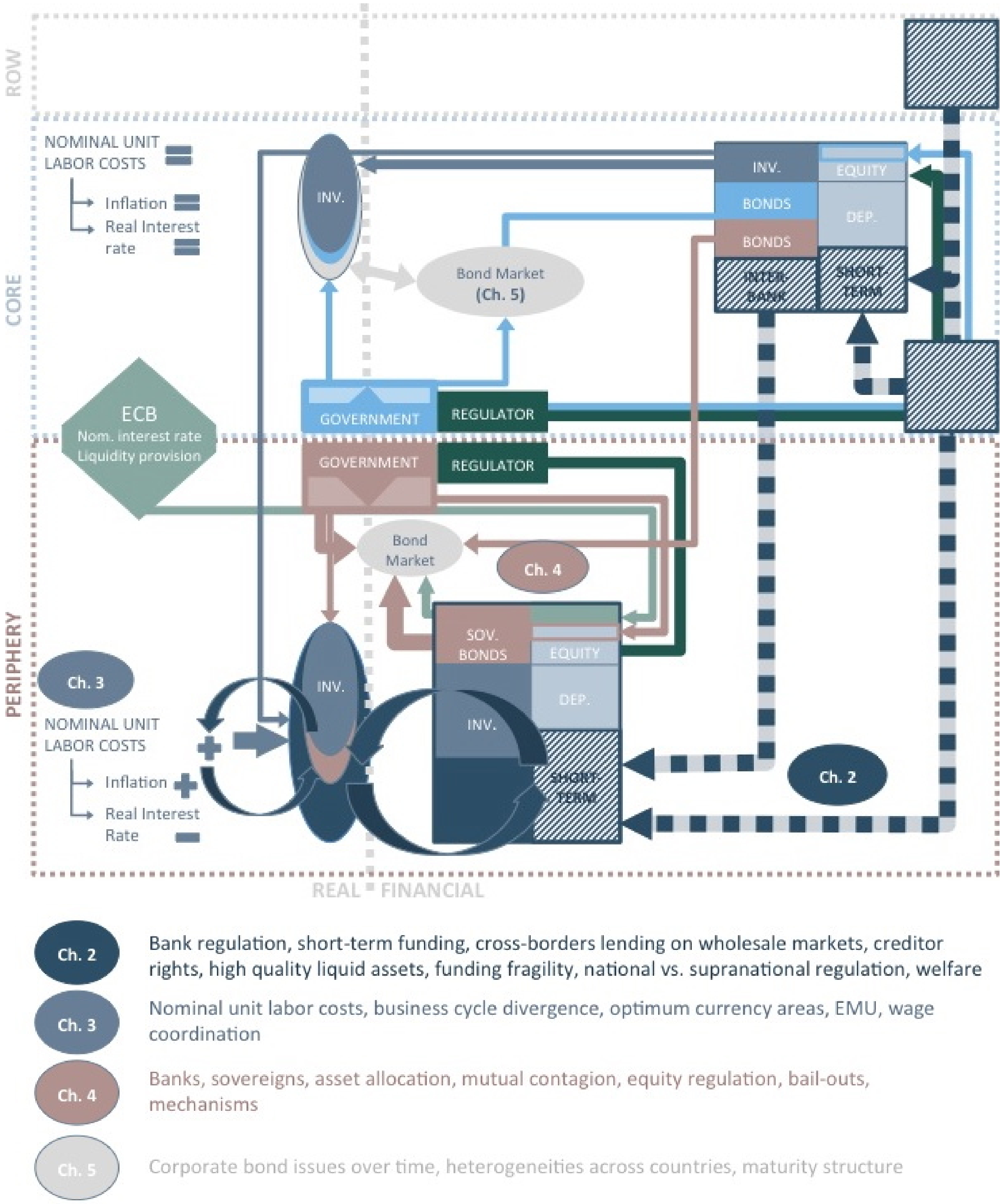
integrated. Some banking systems, for instance, had expanded their cross-border asset and liability holdings to a multiple of local GDP. Numerous institutions had become 'too-big-to-fail' for their home country and regulators saw themselves confronted with considerable governance problems *ex ante* and *ex post* as well as rising debt levels due to costly interventions; especially so when potential bail-outs involved large multinational banks such as illustrated by the cases of Dexia/Fortis and BayernLB/HypoAlpeAdria. In fact, Laeven and Valencia (2012) estimate that the financial crisis and rescue packages for distressed financial institutions account for a 20 percent rise of the euro zone's overall debt level and for 31 and 73 percent of the Spanish and Irish ones, respectively.

A novel strand of literature analyzes these issues empirically and from a theoretical perspective. Gennaioli et al. (2010), Bolton and Jeanne (2011), Acharya et al. (2011a), Acharya and Steffen (2014), Reinhart and Rogoff (2011) as well as Cooper and Nikolov (2013) serve as excellent examples. It is interesting to note that the euro area's stock of public debt in 2012 amounted to 'only' 87 percent of GDP, compared with over 100 percent in the US. Fiscal risks from an individual country's point of view, however, were often exorbitant. The banks' vulnerability consequently caused severe problems for some sovereigns: either implicitly – by the sheer danger of their default or by slowing down the country's economy, which ultimately lowered the relevant tax base, or explicitly – when the sovereign had to intervene with bail-outs, guarantees or other forms of support. The result was the infamous bank-sovereign nexus and spillovers in both directions. A vicious spiral emerged that could only be overcome by massive and coordinated interventions of governments and central banks around the globe.

> *'As banks' assets were not well allocated, nor well diversified geographically, they were more vulnerable to domestic shocks. And as their foreign liabilities were mainly interbank, i.e. not equity-based and short-term, they could not share the subsequent losses with other jurisdictions. This meant that when the crisis hit, the cost of repairing their balance sheets fell largely on their domestic fiscal authorities. The result was the infamous bank-sovereign nexus that has perpetuated financial fragmentation in the euro area.' (Draghi, ECB (2014b))*

1.2.5 Bond financing

As governments were struggling, cross-border capital flows were reversing, and banks were deleveraging, the environment for 'normal' firms worsened as well. European corporations had been relying on bank financing for decades while their US counterparts have traditionally tapped the bond market much more aggressively. European bond markets are therefore still underdeveloped. As companies were overly dependent on the troubled banking sector, they underwent a particularly difficult time period during the ongoing banking and sovereign debt crisis. Although there is evidence that



Ch. 3: The introduction of the euro eliminated differences in national policy interest rates. Investment opportunities in euro zone's periphery were abound. Unit labor costs increased above what would have been justified by long-lasting productivity trends; especially so in the GIIPS. Demand and inflation were pushed upwards and real interest rates in the GIIPS declined. GIIPS governments also could take on debt too easily as markets failed to discipline them and interest rate differentials on public debt vanished; banks were eager to buy their bonds due to zero-risk weights; governments pumped capital into their local economies. Business cycles diverged and considerable imbalances emerged. **Ch. 2:** Banks and pro-cyclical bank regulation fueled local credit booms in the GIIPS; additionally, banks in the core countries lent money to their peers in the periphery on the interbank market; short-term wholesale funding boomed as local deposits did not grow fast enough to finance banks' balance sheet expansion. Equity remained low as risk weighted assets decreased. When the crisis erupted short-term wholesale funding evaporated; capital was flowing out of the periphery; public debt levels increased; **Ch. 4:** negative spillovers between banks and sovereigns occurred; government guarantees protected depositors but drove up public debt, banks' sovereign bond holdings depreciated, banks could no longer provide loans to firms; **Ch. 5:** European bond markets were not sufficiently developed to compensate for that, particularly not in the periphery. Regulatory actions post crisis should increasingly consider cross-border issues, macro-prudential and systemic issues, as well as diverging labor cost developments and the interconnections between banks and sovereigns; national regulators and their representatives in European institutions behave opportunistically; capital market funding must be strengthened.

FIGURE 1.1: Schematic representation

the use of direct capital markets funding has gained momentum during recent years, there seems to be substantial room for improvement. The European Capital Markets Union (CMU) tries to enhance direct capital markets financing and has thus made it to the top of the political agenda in recent months:

> *'The economic and monetary affairs committee wants to see a balanced approach under the CMU in Europe. It believes that reliable non-bank sources of finance should be further developed alongside well-established bank financing. EU businesses will be less vulnerable in the event of tighter bank lending if market participants are able to raise debt, equity and venture capital directly from the market, says the committee. (European Parliament, 2015)*

It is the CMU's primary goal to reduce frictions due to financial constraints. During recessions, for instance, it must be possible for European firms to resort to alternative funding sources. Doing so allows them to better exploit their growth and investment opportunities. On aggregate, a healthy corporate sector creates jobs and fosters a dynamic economic environment, in which public and private debt levels may be brought down from their currently high levels. Efficient policy designs, however, require a deep and comprehensive understanding of the challenges they are facing and the markets they are trying to regulate or develop. With regards to European bond markets, though, there is hardly any such information. Academic contributions have overwhelmingly focused on the US, used theoretical methods instead or exclusively investigated the choice between bank loans and bonds; Holmström and Tirole (1997), Bolton and Scharfstein (1996), Bergloff and von Thadden (1994), Denis and Mihov (2003), and Bolton and Freixas (2000) serve as prominent examples for the last category. DeFiore and Uhlig (2011), who compare US and European bond markets, are a notable exception. They find in their empirical analysis that the lack of information on corporate risk in Europe constitutes a major impediment. It drives up interest rates and deters firms from tapping the capital market in the first place. Similarly, Crouzet (2014) calibrates a model which shows that asymmetric shocks generate deeper recessions in bank-dependent Europe than they do in the bond-dependent US. Becker and Ivashina (2013) highlight that crises are a particular problem for relatively small corporations as their access to bond markets is limited or prohibitively costly. Most papers, however, are unable to capture important European specifics and cross-country heterogeneities, which leaves considerable room for novel and policy-relevant research contributions.

1.3 Thesis overview

The papers of this thesis deal with various aspects of the topics discussed in this introduction. First, **chapter 1** proceeds by summarizing key findings of the individual papers, discussing issues with regards to policy implementation, and providing further thoughts. **Chapter 2** subsequently attends to the issues related to the European banking sector's reliance on short-term debt and cross-border refinancing. It is entitled *'Bank Regulation in the Presence of Short-Term Wholesale Funding and Cross-Border Capital Flows'* and is mostly theoretical although it also contains some empirical elements. The model is a novel attempt to study the regulatory challenges that come with the interplay of banks' funding instability due to debt roll-over risk, cross-border refinancing of banks, as well as fragmented deposit insurance schemes. It aims at understanding the complex interdependencies and at deriving best-possible, practicable policy recommendations. The paper motivates regulation by misaligned incentives and a failure on the behalf of private agents to account for important social costs. Depositors and the bank's short-term creditors alike fail to discipline the bank. The latter gains from shifting risks from information sensitive short-term creditors to depositors and the deposit insurer (i.e. tax-payers). It does not hold enough HLQAs, grants overly generous creditor rights to short-term wholesale financiers and is implicitly subsidized. The bank's funding side becomes unstable as short-term financiers withdraw their money for excessively noisy market signals; total welfare shrinks. The regulator steps in and, in order to prevent runs by wholesale financiers, prefers to limit the maximum creditor rights the bank can allocate to short-term creditors rather than to introduce minimum HQLA requirements, although the paper also provides empirical evidence for the stabilizing impact of the latter. The regulator's action guarantees the first-best social outcome by improving bank funding stability and lifts banks' refinancing costs thus reducing implicit subsidies to the bank. The fragmentation of deposit insurance schemes destroys welfare when financial markets are so strongly integrated as they are in Europe. This is because expected bail-out costs of large banks may prove to be too sizeable for a small national deposit insurer and therefore cause additional costs. For this reason, the regulator may be inclined to additionally require banks to forgo some risky investments and to hold low-yield HQLAs instead. The establishment of a common European deposit insurance scheme could avoid this and should thus be to the benefit of banks and total welfare. The chapter accounts for important characteristics of Europe and the euro area in particular and derives a set of new findings, which contribute to a more detailed understanding of the interdependencies between financial integration, maturity mismatch in the banking sector, and fragmented deposit insurance schemes. The integrated analysis of these issues, the cross-border aspect as well as the analysis of the two regulatory measures constitute important innovations in a novel research area. These insights aim at providing practicable contributions to ongoing discussions about reorganizing the international financial architecture.

Chapter 3, *'European Business Cycle Co-Movement: The Role of Unit Labor Costs'* addresses the issue of diverging developments of competitiveness across Europe and the imbalances that result from that. The ongoing crisis in the EMU emphatically reminded us of the negative consequences such trends may have. The paper uses a dynamic panel estimator to show that heterogeneous wage-setting behavior with respect to underlying labor productivity developments across the euro zone strongly decreases the co-movement of business cycles. This effect had been ambiguous in theory. While the economic significance of this finding is surprisingly large within the EMU and even exceeds the influence of bilateral trade relations, it does not matter for non-EMU countries. The co-movement of business cycles has been established as the meta-criterion to measure European integration in the literature. The underlying idea is simple: If wages in a country within a monetary union increase faster than labor productivity, this country's relative competitiveness suffers. Due to the lack of an exchange rate mechanism, this cannot be compensated for. While domestic demand as well as capital inflows are initially stimulated if wages are increased strongly, balance account deficits build up over time. The larger the differences in wage-setting across countries are throughout the years, the more severe these distortions become. When EMU member countries follow diverging economic trends, the common monetary policy of the ECB becomes increasingly inefficient as the 'one-size-fits-all' interest rate is then no longer suitable for all economies. This in turn compromises the monetary transmission channel and decreases overall welfare of the euro zone. The paper thus provides a powerful argument for directing stronger attention to wage-setting coordination across member countries. This finding also suggests that monitoring systems concerning nominal unit labor cost (NULC) development – as implemented by the European Alert Mechanism – may not be enough, but should be backed up by relative NULC divergence measures between countries as well. Labor cost developments within the EMU have been vividly discussed in recent years. Surprisingly, however, this study is the first empirical contribution on that topic in the academic business cycle literature.

Chapter 4 then turns to the interdependencies between bank and sovereign risk. It is entitled *'Banks and Sovereigns: A Model of Mutual Contagion'*, uniquely addresses the spillover effects between the financial sector and public finances and investigates whether deposit insurance schemes impact positively or negatively on sovereign risk and domestic welfare. The bank experiences an initial shock on its loan return. Since its fate is linked with that of the sovereign because of deposit insurance and the tax base, the latter may default as well. Multiple equilibria may arise. Importantly, the government can cause or prevent its own default by providing deposit insurance. Whereas the former effect dominates whenever the costs of a disorderly bank liquidation are small the latter tends to dominate otherwise. A sovereign default, which – unlike in other papers – is based on fundamentals and obligations towards a deposit insurance scheme rather than strategic decisions, also makes it possible to impose parts of the government's debt burden onto foreign bond holders. A negative feedback loop, in which the bank is hit by the shock but ultimately fails because of the bad performance of the government, comes into play when the bank is invested in sovereign debt. It only chooses to hold sovereign bonds because regulators prescribe zero risk weights for exposures to the latter but positive ones for loan investments. Interestingly, we also find that higher bond returns on sovereign debt, which reflect higher default risk, may even make banks more stable as they provide a buffer for weaker loan performance. This relationship, however, only holds within a group of rather safe countries and reverses otherwise. Stricter capital requirements tend to reduce sovereign and bank risk although the model also hints at possible counteracting effects. Although beyond the scope of our analysis, the fact that bailing out depositors is almost always the sovereign's optimal policy response once a bank defaults, suggests that depositors have no incentive to engage in costly monitoring and will not threaten to run on the bank. This, however, challenges one of the main building blocks of numerous models in this field such as Diamond and Rajan (2001), who claim that fragility is a necessary feature of the banking sector, or Calomiris and Kahn (1991). These findings support the critique of Rochet and Tirole (1996), who show that the anticipation of *ex post* bail-outs may undermine these positive effects, and Pfleiderer (2014) and Admati and Hellwig (2013a), who doubt the disciplining impact of short-term debt.

Finally, **chapter 5**, *'Corporate Bond Issues in Europe Before and During the Financial Crisis'*, investigates the bond issuing behavior of European corporations between 2004 and 2012. The bond market is likely to play an increasingly dominant role in Europe, where firms have been overly dependent on bank loans for long, particularly so because banks are cutting back on balance sheet intensive lending. There is surprisingly little information about the heterogeneities across European countries with regards to companies' use and access to capital markets. This paper provides a comprehensive analysis for which it uses a self-compiled dataset, which reflects the rich interplay between firms' balance sheet characteristics, their location as well as macroeconomic indicators. The paper derives three key results: First, many companies issued more bonds during the ongoing crisis than before. This is especially true for large multinational firms. Second, companies in the euro area's periphery could not increase their capital markets funding as much as their peers in the core countries of EMU. Third, the maturities of new issues were significantly shorter for Italian companies post crisis, while corporations in the core even extended their maturities. These novel findings on European bond markets raise awareness for the fact that a firm's location plays a decisive roll for its refinancing options even when a number of other impact factors are controlled for. This is especially true for smaller corporations. Such constraints may inhibit the economic recovery in the GIIPS and may make firms more vulnerable to shocks hitting the banking sector. The Capital Markets Union (CMU), which is currently in the planning, may therefore mitigate important inefficiencies and provide the basis for significantly improved access to finance, especially so for small and medium sized firms in Europe's periphery.

1.4 Policy implications

1.4.1 Financial integration vs. fiscal protectionism

All chapters contribute to the existing literature in important ways. They also contain several decisive policy suggestions on how to increase social welfare by fostering financial stability and sustaining economic integration in the EMU. Most importantly, the euro zone must be seen as an integrated entity. In recent years, however, the actions of European policy makers have frequently been shaped by protectionism and vested national interests. These standpoints were often an immediate consequence of democratic pressures in their home countries. In fact, Rodrik (2000, 2010) claims in his 'political trilemma' that economic integration, political democracy, and the nation-state are irreconcilable and that we can have at most two at one time.[11] Due to this revived protectionism, banks in particular see themselves confronted with numerous new regulatory requirements which often differ across jurisdictions. Compliance with these varying standards increases complexity and operating costs without necessarily improving financial stability. The growing fragmentation is in fact a threat to cross-border flows of capital and economic growth. Hence, supervisory and regulatory clashes across Europe must be ironed out to create a level playing field. Less protectionism alone, however, will be insufficient. Instead, financial integration must be accompanied by fiscal integration as well. When money is flowing freely across borders, imbalances are inevitable. Catching-up processes and local booms always attract foreign capital. The financial sector's concentration in selective jurisdictions aggravates the cross-border exposure and its excess elasticity promotes dangerous asset bubbles. Although such investment flows have significant advantages in terms of efficient capital allocation and reduced frictions, recent experiences have also highlighted their enormous downside risk, especially so when the financial industry is insufficiently prepared, when considerable imbalances exist and when fiscal budgets are fragmented. Obstfeld (2013), the new chief economist of the IMF and a leading expert on international financial architecture, therefore calls for a centralized fiscal backstop as banking rescues of large cross-border institutes may go beyond national fiscal capacities:

> *'the 2000s saw remarkable worldwide growth in capital flows and banking, both domestically and across borders, but it was especially strong within Europe, in part due to the increasing (and policy-driven) integration of euro zone financial markets. That development, however, undermined the ability of some member states credibly to backstop their national banking systems through purely fiscal means. I propose a*

[11] Rodrik's model is very similar to Mundell-Fleming's 'impossible trinity' principle. The latter states that it is not feasible to have fixed exchange rates, autonomous monetary policy and full capital mobility at the same time; see Baldwin and Wyplosz (2012) (p. 361â€“367) for a more detailed discussion.

new policy trilemma for currency unions like the euro zone: Once financial deepening reaches a certain level within the union, one cannot simultaneously maintain all three of (1) cross-border financial integration, (2) financial stability, and (3) national fiscal independence. (Obstfeld, 2013)

1.4.2 Suggested policy measures

Hence, reduced barriers must be accompanied by **appropriate policy measures. The papers in this thesis suggest several possibilities:** *First,* the European system needs a common supervisor who accounts for Europe's idiosyncracies. The latter must monitor (i) banks' dependence on short-term funding and bank stability in general, (ii) cross-border capital flows through and outside of the banking system, (iii) national wage-setting, (iv) the interdependence between bank and sovereign risk, (v) firms' access to capital markets, as well as (vi) fiscal and other imbalances. *Second,* the funding and maturity structure of banks deserves greater attention. Roll-over risks of banks' wholesale funding as well as harmful risk-shifting incentives between equity holders and creditors, but also between different debt categories, are often substantial. The investigation of the latter in particular is an important novel contribution of this thesis. Requirements to hold a sufficient amount of high quality liquid assets as introduced in the Basel III accord must be implemented stringently. Alternatively, one may limit the rights of non-deposit creditors, i.e. the share of the liquidation value attributed to wholesale financiers as opposed to depositors. The latter could be implemented by automatic stays, deferred payouts, redemption fees, or bail-in rules. Recent European legislation concerning the banking union contain such a bail-in element.[12] *Third,* equity requirements must be increased to reinforce the resilience of the banking sector. Higher equity provisions also reduce implicit subsidies, alleviate important agency costs and forestall the emergence of 'too-big-to-fail' national champions in the banking industry. *Fourth,* the relative wage-setting behavior across the currency area should be monitored to prevent diverging levels of competitiveness. Interestingly, the principal danger of such developments has already been highlighted in the seminal theoretical contributions on optimum currency areas half a century ago (Mundell, 1961; Fleming,

[12] As of 2016, in all resolution cases, the Bank Recovery and Resolution Directive (BRRD), which is applicable to all 28 EU member countries, will require a bail-in of shareholders and creditors equal to at least 8 percent of total liabilities of a given bank, including own funds. Only after the 8 percent threshold can money from the resolution fund be used and for a maximum amount of 5 percent of total liabilities (including own funds) of the bank under resolution. Public money, either from national governments or from direct European recapitalisation of banks, can only be used at the very end of the process which, in practice, should happen exceedingly rarely. Bail-in of shareholders and creditors plus the use of the Resolution Fund should in most conceivable cases, be enough to ultimately cover for the losses incurred by the bank ... Although uninsured deposits from individuals and small firms come last among liabilities possibly subject to bail-in, they would be included if needed to attain the 8 percent total. According to the new rules, only insured deposits are totally excluded from the bail-in tool (ECB, 2014a).

1971; McKinnon, 1963; Friedman, 1953). Although the Maastricht treaty was strongly inspired by these insights, and despite numerous empirical contributions on that topic in recent decades (Frankel and Rose, 1998; Darvas et al., 2005), labor cost variables have not yet been investigated empirically in this context. Chapter 3 thus provides new academic insights and makes a convincing case for more wage coordination within the EMU. On an absolute basis structural reforms must aim at increasing competitiveness in the euro zone as a whole. Monetary interventions alone – although appropriate in the short-run – cannot be a permanent solution and may create additional risks such as inflated asset prices. *Fifth,* micro-prudential banking supervision by itself is incapable of ensuring the overall stability of the financial sector. Hence, it should be complemented by a powerful macro-prudential tool-kit. A common supervisor should be able to curb regional credit booms by counter-cyclical capital buffers and to monitor cross-border capital flows, for example. Accounting for these heterogeneities among member countries reduces dispersion, economic imbalances, and systemic risk. Monetary policy can thus remain focused on euro area aggregates and unconventional policy tools such as the ECB's ABS (asset backed securities)-purchase programme become obsolete. *Sixth,* the academic literature must not produce bookshelf models that may be used to justify and lobby harmful policies. *Seventh,* fiscal discipline of individual countries must be secured. Violations of fiscal targets must be punished consistently and public debt levels should be reduced – on a country-level but also for the currency area overall. *Eighth,* governments may prevent or trigger their own default by bailing-out depositors. The outcome depends on the exact constellation on the sovereign's ability to impose public debt on foreign agents. *Ninth,* EMU institutions must be provided with sufficient financial fire power for bank bail-outs. Fiscal fragmentation is incompatible with free capital flows and other forms of financial integration. *Tenth,* such provisions should be accompanied by credible and binding rules concerning the resolution mechanisms of European banks – including the largest institutions. *Eleventh,* firms need alternatives to bank loans; this is especially true for small and medium sized enterprises. Capital markets and cross-border investments should therefore be strengthened. For that purpose national differences with respect to taxation, payments and security settlement systems as well as insolvency law should be levelled out. Capital market fragmentation and cross-country variation appears to be strong which may inflict significant damage to corporates located in the 'wrong' nation.

1.5 Implementation

The concrete **implementation** of these points may often be rather tricky. An unreflected introduction of all points may in fact undermine their success.

1.5.1 Potential issues

First, many recommendations come at a partial loss of fiscal sovereignty. A fully fledged fiscal union thus currently seems to be out of reach from a political perspective. Nevertheless, first steps towards a central fiscal authority have already been taken. It is important in this context to keep in mind that the simultaneous implementation of fiscal centralization and national countries' discipline is a delicate balancing act. After all, the implicit reliance on financial assistance from other euro area members has repeatedly proven to generate important moral hazard issues in the past. The deficit rules outlined in the Maastricht treaty, for example, have been violated frequently. Angela Merkel's original proposal of making financial assistance out of a euro-zone 'fiscal-capacity' strictly conditional on the success of structural reforms may thus help ensure compliance and prevent the 'mutualization' of debt (Bloomberg, 2012). Recent proposals from the newly elected EU commissioners Moscovici and Dombrovskis may revive fruitless previous attempts in that direction (Handelsblatt, 2014).

Second, profound structural adjustments are painful and subject to political rigidities. Unorthodox and expansive monetary interventions may thus offer a convenient way out. In fact, Ernst Baltensperger, the respected Doyen of Swiss monetary policy, questions the role of the ECB in this regard. He describes recent measures as risky and 'adventurous' attempts to alleviate the problems of EMU member countries and their banks and explains that such actions cannot solve the underlying fiscal and structural deficits (NZZ, 2015). The ECB's role in the decisive phase of the Greek debt negotiations in June/July 2015, for instance, is highly questionable in this regard as well since the central bank's failure to cut-off insolvent Greek banks from emergency liquidity assistance, a violation of its own rules, as well as the threat to do so if Greece would not negotiate with its creditors is a very political decision that may be considered incompatible with the ECB's claim to be an independent central bank.

Third, the new double mandate of the ECB bears considerable risk. While the central bank continues to steer monetary policy, it is now also supervising Europe's largest banks. Hence, situations may arise in which it might be tempted to be overly lenient on the former in order to compensate for a tougher stance on banks and *vice versa*. Political leaders may also use their influence on the ECB to postpone painful structural reforms. Jakob Vestergaard from the Danish Institute for International Studies, for instance, recently noted (based on own calculations) that *'The ECB wanted to appear tough, but it still couldn't show big German, French banks as under-capitalized for political reasons'* (Bloomberg, 2014b). Similarly, Axel Weber (2014), chairman of UBS and former President of the Bundesbank, recently reasoned as follows:

> *'... I see potential conflicts of interest between the ECB as the supervisor and the ECB as the monetary policy authority ... one needs to make a clear separation between*

> *supervision and monetary policy and I believe the current set-up, although with the best intentions, is a delicate one. For the 130 largest banks, the ECB is the 'lender of last resort', determines deposit and refinancing rates, enforces liquidity and leverage ratios, sets capital buffers, and on top of that it should also ensure price stability in the euro area. Truly a conflict of interest minefield!' (Weber, 2014)*

Fourth, banks still hold too much sovereign bonds of their home countries. Such a constellation is problematic as long as the EMU remains fiscally disintegrated. In fact, the banks' exposure exacerbated over the last few years. Domestic euro-area government debt accounted for 4.3 percent of total bank assets in December 2013, up from 3.5 percent in June 2012, when euro leaders launched the banking union, and from 2 percent in September 2008, when Lehman Brothers collapsed (Bloomberg, 2014a). The observation is particularly controversial given that this expansion appears to have been partially financed by the ECB. The latter has been investigated empirically by Acharya and Steffen (2014), who show that the ECB's Long-term Refinancing Operations (LTROs) aggravated the 'home bias' in the periphery, as banks in the GIIPS used the funds to invest into their own sovereigns' debt.

> *'when the ... central bank offered about 500 billion euros of new low-cost liquidity in 2012, lenders used it 'mostly to buy government bonds' (Draghi, Bloomberg (2014a))*

But also banks in the EMU's core appear to have been lured into buying peripheral sovereign bonds by attractive 'carry trade' opportunities, which promised excess returns (Acharya and Steffen, 2014). Concretely, they entered long peripheral sovereign bond positions and financed them by short-term unsecured wholesale funding often absorbed in Europe and the US (Shin, 2012; Obstfeld and Hale, 2014). The banks were hoping to benefit from (i) high interest income and (ii) an appreciation of the bonds when the crises would resolve. They thus generated additional demand for risky bonds and thereby helped the governments to issue debt. The important clean-up of problematic banking sectors and a reduction of public debt was therefore unnecessarily delayed. In fact, bank's exposure to the GIIPS was still going strong in 2010 and 2011. Under-capitalized banks even seem to have been actively seeking these risks (Acharya and Steffen, 2014) due to moral hazard problems as described by Diamond and Rajan (2011). The Belgian Dexia group, for instance, which had already been rescued in 2008, was still heavily exposed to the GIIPS in 2011. When Moody's and Standard & Poor's announced a possible downgrade of the bank, institutional investors started to run on the bank again. US Money Market Mutual Funds withdrew 10 billion USD from the institute in Summer 2011 and 200 billion USD from the European banking system overall (Tarullo, 2012).

Fifth, the bank-sovereign nexus may be unintentionally reinforced by the high quality liquid asset requirements of Basel III as well. The latter allows banks to use sovereign bonds in order to fulfil liquidity requirements. Banks may thus be inclined to further load up on these assets, especially so as long as they keep their zero-risk weight. In combination with banks' documented home bias liquid asset regulation may therefore backfire in this regard. This is especially so because the Basel guidelines, which normally impose haircuts on the eligibility of certain assets according to their risk,[13] allow to use domestic sovereign debt with its full value even it is has been issued by a non-zero risk-weighted sovereign (BIS, 2013). Hence, although chapter 2 of this thesis highlights potentially positive aspects of HQLA requirements per se, a thorough implementation requires for these suggestions to be viewed in interaction.

Sixth, the concrete implementation of the creditor rights constraint as suggested in chapter 2 requires considerable caution: A limit on a bank's wholesale creditor rights may make 'covenant lite' wholesale investments into the bank less liquid. Without a holistic approach towards regulation and a proper regulatory focus on the shadow banking sector, where many of these funds are coming from, risk may therefore be shifted from traditional banks into unregulated shadow banking segments.

Seventh, bond markets must be monitored increasingly carefully as their importance for Europe's corporations rises. This is because bonds are considerably more restrictive during bankruptcy than bank loans in the sense that it is easier to renegotiate repayment conditions with banks than it is with a group of dispersed bond holders. Without appropriate rules and early warning indicators, the stricter covenants on bonds may therefore create instability in the corporate sector. It has become apparent in recent years, however, that the search for yield is currently causing quite the opposite of tight covenants. The low interest rate environment induces investors to give up covenant protection in exchange for higher yields. In a downturn, such securities would be subject to significant liquidity risks and would therefore pose a significant threat to financial stability.

1.5.2 Politics

All points are also subject to political rigidities, particularly so in Europe, where policy makers are striving for economic prosperity, budget restructuring and financial stability simultaneously and where they have to accommodate a range of conflicting arguments articulated by regulators, bankers, academics as well as different national leaders. Anat Admati, for instance, recently commented that:

> *'The euro zone is one of the most dangerous places. I'm a bit anxious about the situation there... The European banking system is in bad shape and it's not easy to change things there, because there is an unhealthy symbiosis between governments and banks, which*

[13] Corporate debt securities rated between A+ and BBB-, for instance, are only eligible with a 50 percent haircut as compared to marketable securities from sovereigns and central banks.

need each other and everyone is connected through the currency. This is economically unstable and unhealthy.' (Admati, Globes (2014))

Similarly, Obstfeld (1997) famously described the introduction of the euro zone as 'Europe's gamble' for the very reasons that should prove decisive ex post:

'EMU is a gamble that can be won in the long run only if it overcomes the existing political stasis to force fundamental fiscal and labor market reform in its member states. If Europe's leaders cannot do an end run around domestic opposition in the name of European integration, EMU could prove unstable.' (Obstfeld, 1997)

Political aspects have thus received increased attention on the *applied research* side as well. Allen et al. (2011), for example, shed light on the negotiations surrounding Dexia and Fortis and mention that complicated cross-border defaults of financial institutions have increasingly motivated countries to pursue opportunistic national goals. Also Beck et al. (2011) draw attention to the flawed interests of national regulators. The controversies between Austria and Bavaria about the resolution of the HypoAlpeAdria bank serves as another illustrative example. Significant dissonances also became apparent in Jean-Claude Trichet's letter to Brian Lenihan, the then Irish finance minister, in the midst of the financial crisis. Its recent disclosure by The Economist (2014) launched a heated debate in Ireland and documents the pressure that has been exerted on the country to accept a 67 billion USD European rescue plan. Importantly, the latter included a provision to fully pay back senior creditors, which means that the ECB 'bullied' Ireland into paying back its banks' debt to foreign European banks, a decision it would not have chosen had it acted alone. That standpoint has interestingly been thrown over successively in the political process later on. Hence, national interests, democracy, and the interconnectedness of the financial system seem to stand in constant conflict, a situation which Rodrik (2000, 2010) calls the 'political trilemma of the world economy'. Many countries therefore erect precautionary walls around their domestic financial system. Bloomberg (2014c), for instance, recently reported that the US Federal Reserve would introduce new standards for the operations of foreign banks on US soil. International flows through the banking system are in retreat as a result of such measures (BIS, 2014). This supranational scope raised demands for a common regulator and a more appropriate contractual framework; especially so in Europe where political structures had been outpaced by the speed of financial integration (ECB, 2012). Negotiations about potential treaties placed considerable emphasis on protecting the fiscal integrity of individual countries in an attempt to break the vicious link between sovereigns and banks in a regime in which national budgets and deposit insurance schemes remain fragmented. Bail-in schemes for (international) non-core liabilities, for example, *de facto* limit their relative seniority as compared to core depositors and restrict liquidation outflows to other countries when a bank defaults. As a first result the issuance of senior debt became more expensive for the banking sector and issues plummeted substantially in 2013 (Financial Times, 2013; Lane, 2011).[14]

Profound reforms consequently *'require substantial political capital'* (Draghi, 2014). Eurozone rules may support national governments in this endeavour: *'Historical experience, for example of the IMF, makes a convincing case that the discipline imposed by supranational bodies can make it easier to frame the debate on reforms at the national level ... In particular, the debate can be framed not in terms of whether, but in terms of how reform needs to take place.'* In fact, some suggestions are already partially reflected in recent actions taken by policy makers, regulators and banks. The latter, for example, have increased their capital by 198 billion euros between July 2013 and fall 2014 according to the ECB. European authorities have strengthened the Stability and Growth Pact, launched a mechanism to correct macroeconomic imbalances, and introduced the Single Resolution Mechanism (SRM); and the ECB – within its Single Supervisory Mechanism (SSM) mandate – conducted a comprehensive assessment of the banking sector in the euro zone[15] and will assume bank supervision over the region's 120 largest financial institutions, which account for 82 percent of assets, going forward. Additionally, the Financial Stability Board, under the chairmanship of Mark Carney, has been actively shaping, monitoring and coordinating ongoing discussions on a global level – calling for more resolute rules for the world's largest financial institutions in particular on numerous occasions. The papers in this thesis, however, raise further options supported by a structured theoretical approach and sound empirical evidence. In fact, some policy moves may fall short of the necessary depth and determination. This work may therefore also be interpreted as a call for further actions.

1.6 Outlook

European banking giants such as Banco Santander, BNP Paribas, Deutsche Bank or UniCredit, who are active in many countries across the continent, may be among the biggest beneficiaries of such measures. Fragmented regulations have frequently burdened them with considerable restrictions in the past. In an attempt to shield the country's tax payers from payments for its bankrupt HypoAlpeAdria, Austrian authorities, for example, violated the nation's *ex ante* guarantees and bailed-in non-deposit creditors. Standard & Poor's subsequently downgraded the ratings of three

[14] The International Monetary Fund (2014b), however, argues that deposit insurance is still a major profit generator for the industry as it disincentivizes clients from demanding higher interest rates. In fact, government subsidies of that sort continue to provide global banks with a funding cost advantage of 20 to 90 basis points according to their estimates.

[15] The Asset Quality Review (AQR) involved 130 large credit institutions across 18 member states, which account for approximately 85 percent of euro area bank assets. 25 of these institutions failed this assessment. Only 13 of them, however, need to raise 25 bn USD capital. 12 have already covered their shortfalls.

other Austrian banks, whose funding costs increased as a result. Although nationalistic legislation may be understandable through the lense of Austrian tax payers, it is myopic from a community perspective. The results of this thesis illustrate the superiority of a more integrated view in terms of economic welfare in Europe overall.[16] Unified regulatory environments and supervisory structures also create trust among banks and diminish entry barriers. Consequently, we might see more cross-border mergers and the development of truly integrated European banks. Interestingly, such expectations were recently expressed by Vítor Constâncio, the vice president of the ECB: *'The weak profitability and excess capacity of the European banking sector ... suggests that efficiency gains could be reaped from more consolidation. This, together with the on-going repair of bank balance-sheets, should set the stage some time down the road for a new phase of M&A geared towards improving efficiency (ECB, 2014a).'* Also comments from bankers such as Jürgen Fitschen, Co-CEO of Deutsche Bank, may indicate such a shift in the European banking landscape: *'In our industry, there is still no real European market. Especially the retail business is still largely a national issue ... These units are too small to survive alone in the long term ... This is one of the issues with which we must deal. We are currently represented in the retail business only in a few European countries (Die Welt, 2014).'* A larger home market may allow the major institutions to realize sizeable economies of scale and to successfully compete with their US and Asian counterparts. This may also be favorable for their clients in the 'real sector', who can then choose from a broader range of valuable financial services, which can only be offered profitably by big pan-European financial institutions. However, consolidation and a level playing field may favor the emergence of even larger banks. These must be allowed to fail. Intelligent bank regulation is therefore crucial in this context. Smaller banks, on the other hand, would especially benefit from reduced complexity of the regulatory system. Clear and simple rules lower their operating costs, improve transparency and prevent them from becoming 'too-small-to-survive'. A uniform resolution mechanism and a supranational fund to wind down insolvent banks – as envisioned by the European banking union – can potentially break the unfortunate link between banks and public finances, which has caused major problems during the European debt crisis when various countries became the subject of financial speculation. The banking union in its current form, however, may not be sufficient yet. Paul De Grauwe, a leading expert on European integration, for instance, expressed deep scepticism about the announcement of its initiation in the current form:

> *'The key to the banking union is an authority with financial clout. They don't have it so we don't have a banking union ... The whole idea was to cut the deadly embrace*

[16] The case of UniCredit/HypoVereinsBank is another example. In 2011 the German bank regulator BaFin forced HVB to refrain from transferring excess equity to its Italian parent company UniCredit in order to prevent indirect payments for the Italian economic crisis. The case has later been investigated by the European Commission with regard to its compatibility with the principle of free movement of capital.

between bank and sovereign. But if a banking crisis were to erupt again, it would be back to how it was in 2008 with every country on its own.' (De Grauwe, 2014)

Further political measures are thus indispensable. These must be complemented by more coordinated wage-setting and fiscal discipline within the euro zone as well as higher bank equity requirements, efficient liquidity provisions and the creation of a capital markets union, which improves the access to bond markets as an alternative to bank loans. In order to alleviate problematic risk-shifting, a particular focus should be placed on smarter regulation of banks' short-term financing and their specific liability structure. Cross-border capital flows within Europe are desirable but should be accurately monitored and moderated with appropriate macro-prudential tools. If implemented, the EMU may move closer to being an optimum currency area, which is less susceptible to systemic shocks and more efficient in terms of capital allocation, political governance, and monetary policy transmission. A fully fledged European banking union, intelligent bank regulation and coordinated wage-setting may thus prove to be important milestones for a more integrated and prosperous European economy, which efficiently taps its full economic potential.

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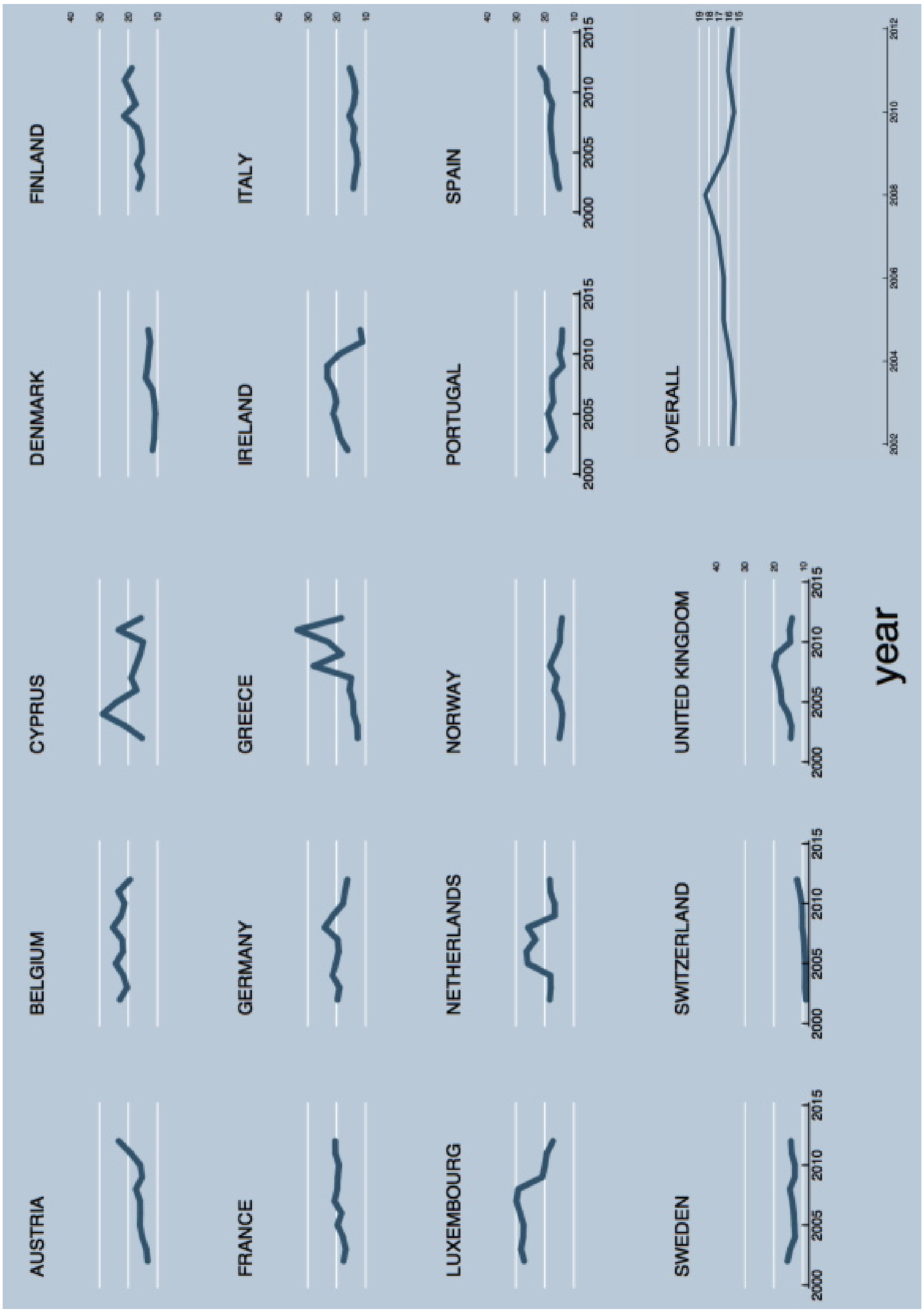
Appendix



The graphs show the average leverage ratio of each country's banks over time between 2001 and 2012. The leverage ratio is defined as the ratio of the book value of assets to the book value of equity. Data is sourced from Bankscope. Swiss banks featured the lowest leverage ratio throughout the period under review, which may be a consequence of the focus on private banking and asset management, i.e. a less balance-sheet intensive business model. The graph at the bottom right shows the average leverage ratio across all countries, which reached its maximum (about 18.5) just before the onset of the financial crisis.

FIGURE 1.2: Avg. leverage ratio of commercial banks overall and by country over time

Chapter 2

Bank Regulation in the Presence of Short-Term Wholesale Funding and Cross-Border Capital Flows

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2 This paper has been presented at the Annual Meeting of the Eastern Finance Association in Pittsburgh (USA), the Conference of the Western Economic Association in Denver (USA), the Accounting/Finance Seminar at Stanford Graduate School of Business (USA), the Swiss Meeting of Young Economists at the University of Bern (CH), the Lindau Meeting for Nobel Prize Laureates in Economics (DE), as well as the Economics and Finance PhD seminar, the PiF Seminar at the School of Finance, and the Economics Brown Bag Seminar at the University of St. Gallen (CH).

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Abstract

I present a model in which banks rely on insured deposits as well as local and foreign wholesale funds. I analyze how profit-maximizing banks choose their asset mix of high quality liquid asset (HQLA) holdings and more profitable, risky investments and how they determine the level of creditor rights they allocate to depositors and wholesale financiers. I show that regulation is optimal if banks make choices, which render them vulnerable to runs from wholesale financiers upon overly noisy market signals. Such withdrawals cause inefficient bank liquidations, reduce expected welfare and shift risk to the deposit insurer. A regulator may consequently force banks to hold minimum HQLAs and/or to limit the creditor rights of their wholesale financiers. I demonstrate that he usually opts for the latter. This intervention establishes the first-best outcome by improving bank funding stability and reduces implicit bank subsidies by lifting the refinancing costs of banks. Expected bail-out costs of large banks may still prove to be sizeable for a small national deposit insurer, however, and therefore cause additional costs. This may induce the regulator to additionally require banks to forgo some risky investments and to hold low-yield HQLAs instead. The establishment of a common European deposit insurance scheme could avoid this and should thus be to the benefit of banks and total welfare. The novel predictions of the model are broadly consistent with recent developments and policy decisions with regard to the European banking system and are of particular importance for evaluating current attempts to reshape its supervision.

JEL classification: G01, G21, G28, F32, F34

Keywords: *Optimal Bank Regulation, Short-Term Funding, Cross-Border Capital Flows, Financial Fragility, High Quality Liquid Asset Requirements, Creditor Rights Regulation, Common European Deposit Insurance, Welfare*

'Some have argued that ... the fear that deposits or short-term debt might be withdrawn (or not renewed) leads managers to act more in line with the preferences of creditors and other investors in the bank... In fact, it creates significant frictions and governance problems ... quite the opposite of 'discipline." (Admati et al., 2013)

'left to their own devices, unregulated banks may engage in excessive money creation and may leave the financial system overly vulnerable to costly crises.' (Stein, 2012)

'During the early 'liquidity phase' of the financial crisis that began in 2007, many banks - despite adequate capital levels - still experienced difficulties because they did not manage their liquidity in a prudent manner.' (BIS, 2013)

'I am not concerned about capital flows per se ... Previous interest rate differentials had been very high and had contributed to preventing capital from flowing to destinations where it would be most productive ... However, governance mechanisms for these capital flows were insufficient...' (Hellwig, 2011)

'Without credible cross-border resolution regimes, banks are global in life; national in death ... particularly ... in the EU, where there is a common market for banking services but not yet a common strategy or fund for bank resolution.' (Acharya et al., 2014)

Financial integration before the crisis was incomplete. '...while euro area interbank markets became almost completely integrated, retail banking integration remained largely fragmented ...' That led to a situation where banks used short-term and debt-based funding to increase lending to favoured domestic sectors such as real estate. 'As banks' assets were not well allocated, nor well diversified geographically, they were more vulnerable to domestic shocks. And as their foreign liabilities were mainly interbank, they could not share the subsequent losses with other jurisdictions ... when the crisis hit, the cost of repairing balance sheets fell largely on their domestic fiscal authorities ...' (Summary of Mario Draghi's speech on the occasion of the 20th anniversary of the establishment of the European Monetary Institute (ECB, 2014))

2.1 Introduction

The funding pattern of European banks underwent dramatic changes over the last twenty years. This development was predominantly fueled by the introduction of the euro and local asset booms in Europe's periphery during the run-up to the recent financial crisis. Deposit growth in the periphery could not keep pace with these (long-term) investment opportunities. Between 1999 and 2008 the average loan-to-deposit ratio decreased from 1.16 to 1.14 in Europe's core countries while it increased from 1.16 to 1.49 for banks in the periphery (see figure 2.1). The latter consequently absorbed short-term funds from wholesale money markets such as money market mutual funds (MMFs)[4] or interbank loans instead. The banking sector's balance sheet expansion during that time was therefore almost exclusively short-term funded as exemplified for Ireland in figure 2.1.[5]

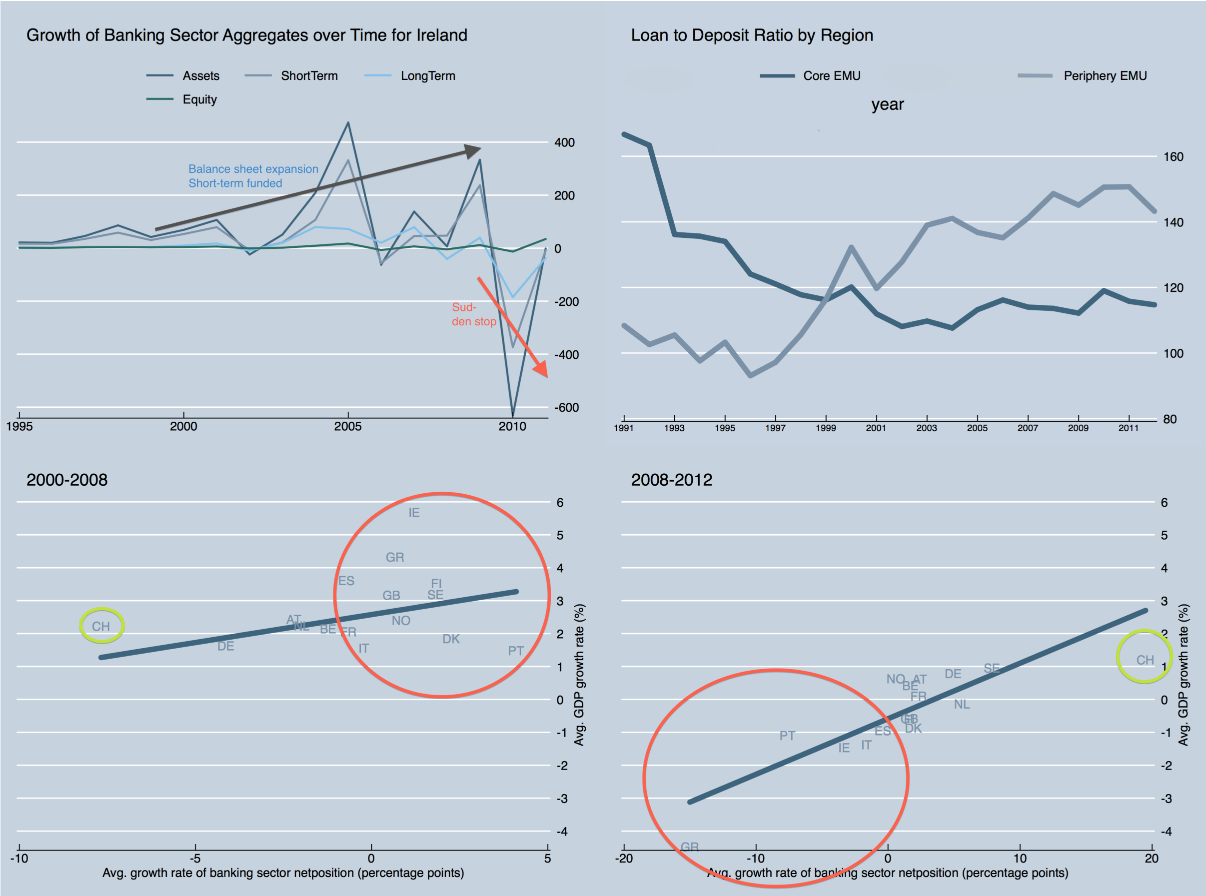
Banks sourced a considerable fraction of these loans abroad. Hence, cross-border interbank-lending of European banks increased five-fold between the introduction of the euro and 2008. Particularly German, British, French and Swiss institutions accumulated considerable gross positions.[6] Spanish, Greek and Portuguese banks were the largest net recipients these funds and thereby facilitated economic growth in their home countries. Figure 2.1 illustrates the correlation between GDP growth and the average percentage change of the banking sector's foreign net position, measured as foreign liabilities minus foreign claims, for the pre-crisis period as well as for the crisis years. The differences between the two time frames are striking: The GIIPS (red circles) were among the fastest expanding economies before the turmoil when their banking systems' foreign net position was growing above average, but among the most rapidly contracting after when foreign European capital flows were reversing at a massive pace. To make things worse, US MMFs abruptly pulled back their lending as well. In 2011, for example, they reduced it by roughly 200 billion USD over just four months (Tarullo, 2012). The exact opposite holds true for 'safe haven' countries such as Switzerland (green circle), whose banks initially pumped money into faster growing regions but attracted sizeable inflows afterwards.

Regulation has often been too lenient in this context or simply incomplete and misdirected. Banks were free to choose very generous contractual terms with their wholesale creditors. Additionally, the latter benefited from information advantages over other financiers. In conjunction with the short-term nature of these funds, this meant that they were able to secure sizeable parts of bank liquidation values and to 'outwit' tradi-

4 95 percent of European MMFs, which manage assets of roughly 1,000 billion Euros and hold 38 percent of banks' short-term debt, are located in France, Ireland or Luxembourg (European Commission, 2013).

5 All graphs and tables are based on own calculations. Further graphs and a detailed discussion of the data and the empirical results can be found in sections 2.C to 2.E of the appendix.

6 See figure 2.19; gross positions are calculated as the sum of foreign claims and liabilities.



Top-left: bank balance sheet expansion funded by short-term debt rather than long-term obligations and equity; Top-right: short-term wholesale funding as deposit growth cannot keep pace with the investment opportunities; particularly in the euro zone's periphery. Bottom-left: interbank market channels funds from banks in Europe's core to their peers in the periphery pre crisis; Bottom-right: sudden reversal during crisis.

FIGURE 2.1: Funding pattern of Europe's banks: Non-deposit, short-term, cross-border

tional retail depositors. While depositors provided cheap and stable funding as they were protected by deposit insurance, short-term wholesale financiers thus liquidated their positions rather aggressively. Roll-over decisions of wholesale financiers came up on a frequent basis and every withdrawal eroded the banks' high quality liquid asset (HQLA) holdings. These buffers decreased most for banks in troubled economies such as Italy, Spain and Greece. Runs were therefore mostly launched from wholesale creditors rather than depositors (as in previous banking crises). Indeed, Shin (2008) highlights that banks often had already exhausted their HQLA reserves to pay off their short-term wholesale financiers when depositors started to run on the bank; especially so because reserve requirements were small to begin with. Banks were consequently forced to rapidly sell longer term assets as well – often at fire-sale prices. Northern Rock is a prime example for the disastrous consequences abrupt withdrawals generated for individual institutions and the financial system as a whole. These negative effects were magnified by the fragmented structure of European deposit insurance schemes on the national level and the sudden reversal of capital flows.

Regulators have since taken a number of steps to improve financial stability (e.g. ECB supervises largest banks, regulators can liquidate troubled banks more quickly, Bank Recovery and Resolution Directive, Single Resolution Mechanism, minimum HQLA requirements under Basel III). Yet, preceding negotiations have been challenging and many planned reforms could not be implemented. After all, the importance of the banking sector varies considerably across countries and fiscal budgets and deposit insurance schemes are still fragmented, which incentivizes national ring-fencing and regulatory arbitrage.

The purpose of this paper is to construct a simple model that can reproduce some of the stylized facts reported above and thereby shed light on the underlying mechanisms, inefficiencies and potential regulatory options. It contributes to the literature in five important ways: *First,* it is a novelty to study the interplay of bank short-term funding, wholesale creditor rights, HQLA requirements, cross-border capital flows and fragmented deposit insurance schemes in combination. Previous contributions studied these issues in isolation and therefore failed to account for important specifics of the euro area, where national banking sectors face a limited supply of local deposits and therefore take on short-term debt from foreign banks and MMFs to finance local (long-term) investments and where regulatory choices are made against the background of fragmented fiscal budgets.

Second, the model investigates roll-over risk rather than solvency issues and shows that banks may have incentives to inefficiently shift risk between different debt categories: from short-term wholesale financiers to depositors (i.e. the public). An unregulated bank may do so by holding too little HQLAs and granting overly generous creditor rights to information sensitive short-term creditors, which thus withdraw too often. Financial stability is impaired and depositors have to be bailed-out with public money too frequently. Many recent papers, however, either point out positive effects of short-term funding or investigate bank solvency issues and conflicts between debt and equity holders.

Third, the paper introduces a regulator, which may implement two policy options: (i) a limit on wholesale creditor rights (e.g. delayed pay-outs, lower share of the liquidation value, redemption restrictions) and/or (ii) minimum HQLA requirements for banks. A simple regression for 405 commercial banks in Europe, as shown in section 2.C in the appendix, confirms the stabilizing impact of the latter: Institutions with relatively high ratios of liquid asset holdings to short-term funds were in fact less likely to experience abrupt withdrawals of that form at the onset of the crisis. Concretely, a 100 percentage point higher ratio reduced the likelihood of short-term outflows by 1.5 percent. The paper investigates the impact of both options on welfare and elaborates on which one is optimal for which agents under which conditions. Such a comparison has not been done before.

Fourth, the model provides new insights on the international dimension: It demonstrates why the regulatory choice in a scenario with common deposit insurance may deviate from the one in a framework with fragmented insurance schemes in the presence of cross-border capital flows. The regulator in a fragmented system may choose to constrain creditor rights and to require minimum HQLA buffers simultaneously in situations in which the regulator in a scenario with common deposit insurance would instead opt for the creditor rights limit only. This avoids fragmentation costs during bank default but constrains the investments into riskier, more profitable projects.

Fifth, the paper proposes a novel explanation as to how banks could benefit from the establishment of a common European deposit insurance scheme. The model's insights are broadly consistent with recent developments and policy decisions with regard to the European banking system and are particularly relevant for evaluating current attempts to reshape its supervision, which has shown important deficits in recent years.

The paper starts with a discussion of the related literature in section 2.2. It then introduces the agents and outlines the basic model structure in section 2.3 before section 2.4 shows the benchmark equilibrium. A market update is introduced in section 2.5, which discusses the need for regulation and evaluates available policy options. Section 2.6 investigates the international dimension of the problem before sections 2.7 and 2.8 discuss and conclude. More detailed evidence for the stabilizing role of banks' HQLA buffers during the European crisis is provided in the empirical extension in section 2.C in the appendix.

2.2 Related literature

Recent literature has devoted renewed attention to the topics discussed in the introduction. Huang and Ratnovski (2011), for example, show in a theoretical model that excess *creditor rights* may induce 'informed' short-term wholesale creditors to liquidate banks inefficiently. This finding challenges previous contributions from Calomiris and Kahn (1991), Calomiris (1999) and Diamond and Rajan (2001), which exclusively focus on the 'bright side' effects of short-term wholesale funding, i.e. the fact that it loosens unnecessary investment restrictions and its 'discipling role'. The latter has also been doubted by Acharya et al. (2011), Admati and Pfleiderer (2010), Admati and Hellwig (2013a,b) and Pfleiderer (2014), who describes the disciplining view as a 'chameleon' without real-world validity. Although Huang and Ratnovski (2011) acknowledge that non-core wholesale funding may be particularly useful when credit is growing faster than deposits, which are mostly local and grow with the size of the economy and the wealth of the household sector, they also reveal its 'dark side' when short-term wholesale financiers enjoy overly generous liquidation terms.

The ability of wholesale financiers to reclaim such a sizeable fraction of their initial investment is also based on the *short-term* nature of their funding as highlighted by Shin (2008), Hahm et al. (2012) and Huang and Ratnovski (2011). Farhi and Tirole (2012) and Lane and McQuade (2013) were among the first to stress the banking system's excess reliance on short-term debt, which, according to Tarullo (2014) and Strahan (2012), was increasingly sourced on wholesale markets rather than via traditional retail deposits. Brunnermeier (2009) regards the resulting maturity mismatch as a major accelerator of the financial downturn in 2008 and argues that the panic on money markets contributed to spread financial losses well beyond what sub prime positions would have justified. Also Heider et al. (2015) show that the risks associated with banks' long-term asset holdings can lead to the evaporation of liquidity in the unsecured interbank market. The sheer magnitude of roll-over risks the system had itself exposed to and banks' incentives to take on excess leverage in general (Admati et al., 2012; Pfleiderer, 2010) further multiplied these effects. According to Brunnermeier and Oehmke (2013), the roll-over risk also emerged as a result of bankers' private incentives to engage in what the authors concisely call a 'maturity rat race'. Ultimately, the issue was no longer the cost, but the availability of funding (Brunnermeier et al., 2009; Stein, 2013; Griffoli and Ranaldo, 2010). Perotti and Suarez (2009) thus raise doubts about Basel capital requirements and their sufficiency to cope with systemic risks, while Farhi and Tirole (2012) argue that recent events provide a compelling rationale for a more macro-prudential policy approach that judges interventions based on the status not only of individual financial institutions but of the financial system as a whole. Feldman and Schmidt (2001) and Hahm et al. (2012) suggest a large stock of short-term debt as an important macro-prudential indicator for increased vulnerability and Krishnamurthy and Vissing-Jorgensen (2013), who measure short-term debt to average 66 percent of world-GDP with a peak of 99 percent in 2007, show that short-term debt issued by the financial sector predicts financial crises better than standard measures such as private credit/GDP. Bai et al. (2014) compute a maturity-mismatch measure for the US, which shows that the amount of funds major banks can obtain at a given point fell short of what they needed in order to meet their creditors' claims by 4.35 trillion USD in 2007.

Finally, there is a strand of literature on *cross-border* lending among banks and its implications. Its massive expansion in the euro zone after the introduction of the common currency was first comprehensively discussed by Shin (2012) (p. 41), who writes that the *'asset side remained stubbornly local and immobile while 'money' (i.e. bank liabilities) was free-flowing across borders. As bubbles were local but money was fluid, the European banking system was vulnerable to dramatic runs ...'* According to Borio and Disyatat (2012), the 'excess elasticity' of the international monetary and financial system thus fueled unsustainable credit and asset price booms and created significant imbalances. The quick expansion of cross-border funding – and interbank lending in particular – in the run-up to the crisis was indeed followed by a sudden stop in 2008 and a deep dip thereafter (see, for instance, BIS (2012)). Despite the regulatory challenges that come with such cross-border exposures in the fiscally fragmented euro zone they have so far been under-represented in the academic literature with the exception of policy papers by Beck et al. (2011) and Obstfeld (2013), who claims that one cannot simultaneously maintain cross-border financial integration, financial stability, and national fiscal independence within a currency union.

2.3 Model outline

The following model is a novel attempt to analyze European regulation. In order to conduct an integrated investigation of the five key areas that have been defined above and to capture the full interplay of various important European specifics, it introduces new elements to the model set-up that have not been present in previous research on this topic: First, there is a welfare maximizing regulator who can control the distribution of a bank's liquidation value between short-term wholesale financiers and 'traditional' retail depositors by influencing creditor rights. Second, he may impose minimum HQLA requirements on banks. Third, depositors are protected by a nationally funded deposit insurance scheme. Fourth, it introduces cross-border capital flows as well as costs of nationally fragmented deposit guarantees. These twists generate a framework, from which a number of novel findings are derived.

Consider an economy with four types of agents: a bank, depositors, wholesale funders, and a deposit insurer. Additionally, a regulator maximizes aggregate welfare. There are three dates (0, 1, 2), no discounting, and everyone is risk-neutral.

Bank

A *bank* has exclusive access to a risky long-term investment project in its home country, which yields $X > 1$ at date 2 with probability p and 0 with probability $(1 - p)$. The net present value of this project is positive. If it is prematurely liquidated at date 1, it yields a liquidation value $0 < L < 1$. Alternatively, the bank may invest a fraction h of its funds into a safe asset. The latter can be sold without loss at any time. But it yields a return $R_h < X$, which – for simplicity – is normalized to 1, and constrains the volume of investment into the more profitable project to $1 - h$. The bank has size one and funds itself at date 0 through funds from depositors D and short-term wholesale financiers $T = 1 - D$. If the latter do not roll over at date 1, the bank becomes insolvent and must be resolved.[7] It otherwise absorbs all profits from its investments. A part

[7] This is because the bank must honour its obligations towards creditors by liquidating assets. Since L is sufficiently small, equity is wiped out, which directly triggers resolution. Hence, the model focuses on the implications derived from the characteristics of the two debt categories rather than on the role of equity.

is then distributed to wholesale financiers and depositors via interest rate payments R and R_D conditional on success. The bank incurs no specific default cost and is protected by limited liability. Its expected profit function therefore looks as follows:

$$\pi_B = \underbrace{p(X-1)(1-h)}_{\substack{\text{expected profit on} \\ \text{risky projects}}} - \underbrace{pT(R-1)}_{\substack{\text{expected funding costs paid} \\ \text{to wholesale financiers}}} - \underbrace{p(1-T)(R_D-1)}_{\substack{\text{expected funding costs paid} \\ \text{to depositors}}} \tag{2.1}$$

When resolved, it makes zero profits and its liquidation value is split between the creditors according to their relative rights, s. These creditor rights and the fraction of investments into HQLAs, h, are chosen by the bank at date 0. s should be interpreted as the *de facto* share of the liquidation value that goes to short-term wholesale financiers as opposed to depositors in case of liquidation. Also note the technical constraints $s \in [0,1]$ and $h \in [0,1]$ and that the bank may have to comply with regulatory limits when it determines h and s.

Depositors

Depositors endow the banking system with a fixed deposit base, $D < 1$, for which they receive an interest rate R_D with probability p from the bank. They are protected by a national deposit insurance scheme, which pays D in the bad state, i.e. with probability $1-p$. Since the deposit insurer's commitment is assumed to be both credible and feasible, they are passive, information-insensitive, and never withdraw before date 2.[8] Depositors' expected welfare therefore equals:

$$\pi_D = pDR_D + (1-p)D - D \tag{2.2}$$

Short-term wholesale financiers

Short-term wholesale financiers are sophisticated short-term investors who cannot invest in profitable projects themselves. Hence, they provide funds of size $T = 1 - D$ to the bank and receive an interest rate R as compensation for their risk and cost. The latter is pinned down at date 0, which avoids a hold-up problem at date 1 (Von Thadden, 1995). Short-term creditors receive TR in the last period if the bank's projects are successful, which happens with probability p. With probability $(1-p)$, however, a bad bank eventually goes bust at date 2, at which point only h can be recovered of which wholesale financiers get a fraction s. The short-term creditors' expected welfare function looks as follows:

$$\pi_T = pTR + (1-p)sh - T \tag{2.3}$$

8 This is consistent with Dewatripont and Tirole (1994), who claim that depositors may be too small and dispersed to exercise control over the bank, Rochet and Tirole (1996), who argue that *ex ante* monitoring incentives on the interbank market only work if they are not undermined by the anticipation of *ex post* government bail-outs, as well as empirical observations from Song and Thakor (2007) and the Basel Committee, which considers deposits as relatively more stable if they are insured as shown in table 2.6.

This only holds, however, when T is rolled-over at date 1 in order to avoid bank liquidation in this intermediate period. Similar to Huang and Ratnovski (2011), the amount of wholesale funding attracted by the bank is not insignificant such that:

Assumption 1. *The expected date 2 pay-off of wholesale financiers, i.e.* $pTR + (1-p)sh$*, is equal to or larger than their share of the bank's date 1 liquidation value* $s[(1-h)L+h]$*.*

Wholesale financiers then never withdraw based solely on a prior p to receive $s[(1-h)L+h]$ instead of waiting for $pTR + (1-p)sh$ expected at date 2. 'No news is good news' and bank runs do not occur absent negative information at date 1. Note that all agents prefer bank continuation to liquidation when they are otherwise indifferent.

Deposit insurer

A *deposit insurer* provides deposit insurance and bails-out depositors if a bank defaults, which therefore costs $(1-p)(1-T)$ in expectation. For that purpose, it can deploy a fraction $1-s$ of the bank's liquidation value, i.e. the residual value of the bank after wholesale financiers have extracted their share. The rest must come from other sources.[9] Liquidation occurs with probability $(1-p)$ at date 2, when only h can be recovered. The expected cost of deposit insurance therefore amounts to:

$$\pi_S = -(1-p)(1-T) + (1-p)(1-s)h \tag{2.4}$$

Regulator: A regulator maximizes total expected welfare[10]

$$\pi = p(1-h)X + h - 1 \tag{2.5}$$

which can be obtained by using $D = 1-T$ and summing up over the four agents' individual welfare functions

$$\begin{aligned}
\pi_B &= p(X-1)(1-h) - pT(R-1) - p(1-T)(R_D-1) && (2.6)\\
\pi_T &= pTR + (1-p)sh - T && (2.7)\\
\pi_D &= p(1-T)R_D + (1-p)(1-T) - (1-T) && (2.8)\\
\pi_S &= -(1-p)(1-T) + (1-p)(1-s)h && (2.9)
\end{aligned}$$

For that purpose, he may choose to constrain the maximum share of the liquidation value $s \in [0,1]$ the bank can attribute to wholesale financiers or to impose minimum

9 Note that a deposit insurance scheme funded by the bank itself would be an obvious alternative. The determination of a fair insurance premium for the bank, however, would be extremely difficult in reality. Additionally, the current 55 billion USD fund within the framework of the European banking union is too small to finance systemic bail-outs of depositors. Furthermore, the risks concerning the bank's risky assets $1-h$ are correlated, which is why an insurance scheme would not work.

10 Without short-term funding welfare would be limited to the bank's return on its deposit base D (i.e. $\pi = D(1-h)(pX-1)$), which Song and Thakor (2007) empirically show to be a slow-moving variable.

HQLA requirements $h \in [0,1]$. Within these constraints, the bank can then privately determine the fraction s of the liquidation value it allocates to short-term creditors in the date-0-contract as well as HQLA holdings h. The timeline below summarizes the basic model set-up; a list of notations can be found in table 2.2 in the appendix.

$t=-1$	$t=0$	$t=1$	$t=2$
Regulator may constrain the bank: (a) minimum liquidity requirement (b) maximum creditor rights it can allocate to wholesale financiers	Within regulator's constraints banks choose: - the asset mix, i.e. liquid (h) vs. risky assets ($1-h$) - short-term creditor rights s Depositors and wholesale financiers: - Provide funding to the bank - Impose interest rate	Short-term wholesale financiers roll-over absent new information	Projects mature; Return realizes; Banks collect profit; Depositors and wholesale creditors repaid; Deposit insurance

Figure 2.2: Timeline

In practice, the regulator may alter the maximum share of the liquidation value s the bank can allocate to short-term wholesale financiers rather than retail depositors, by introducing haircuts, automatic stays or deferred payouts for withdrawals. Longer maturities and limited entitlement for on demand payment in full, for instance, are good proxies for less comprehensive rights for wholesale financiers. Alternatively, in order to diminish wholesale' opportunities to front-run traditional depositors, banks may develop products, which allow withdrawals only with some delay, or the regulator may install an authority capable of shutting-down bad banks in a more timely manner.[11] Minimum HQLA requirements h for banks are a promising alternative to the creditor rights constraint.[12] The LCR in Basel III, which prescribes a minimum amount of dollars to be held in HQLAs, is a good policy example for this instrument.[13]

11 The Single Resolution Mechanism (SRM) and the Bank Recovery and Resolution Directive (BRRD), for instance, introduce such regulatory competencies as well as bail-in elements for non-deposit creditors; the 'Limmat'-Transactions in Switzerland 2008/2009 contained a deferred payment element. Such measures eliminate important run-prone features of debt as used in Diamond and Dybvig (1983), where a run develops because a contract promises a fixed value, payable in full on demand and on very short notice, and expressed by Cochrane (2014) (p. 6), who writes that *'if the firm has the right to delay payment, suspend convertibility, or pay in part, it is much harder for a run to develop.'*.

12 Tarullo (2014) describes the new liquidity tools in Basel III as an essential improvement, which will foster financial stability and complement costly lender-of-last-resort services from central banks; Cochrane (2014), who calls for more government backed short-term debt in the economy in general, writes that *'a bank should hold a minimum amount of liquid assets such as treasuries'*.

13 The ratio is defined as 'HQLA over potential net outflows over a 30 days stress period', i.e. $LCR = \frac{\text{Stock of HQLA}}{\text{NO30}}$ (BIS, 2013), has to exceed 100%, and is to be implemented incrementally until 2018 in Europe. HQLAs must be considered sufficiently liquid in periods of market turmoil and, in most cases, be eligible for use in central bank operations; not all assets qualify to the same extent: corporate debt securities rated between A+ and BBB- are only eligible with a 50% haircut as compared to marketable securities from sovereigns and central banks. Table 2.6 presents examples of the Basel Committee's assessment of assets in the LCR's numerator and debt categories in the denominator; a full list can be found in BIS (2013). Recent lobbying efforts of the banking industry have aimed at softening both.

2.4 Benchmark

2.4.1 Market equilibrium

Short-term wholesale financiers and depositors

One can now derive the market equilibrium in a scenario without government intervention in which creditor rights $s \in [0,1]$ and HQLA holdings $h \in [0,1]$ can be freely chosen by the bank. Consider first the *wholesale creditors*. Wholesale markets are fully competitive, which is why they impose an interest rate consistent with their break-even condition $\pi_T = 0$ as an adequate compensation for their risk. Unlike wholesale creditors, retail *depositors* – since deposit insurance makes them information insensitive and passive – fail to impose any conditions on the bank, receive an interest rate $R_D = 1$ and make zero profit, i.e. $\pi_D = 0$.

Bank

With these considerations in mind, the *bank*, which ignores bailout costs for depositors and does not repay creditors in default due to limited liability, maximizes its expected profit (2.6). It obviously has no incentive to pay wholesale financiers more than necessary. From (2.7) one can derive the wholesale financiers' participation constraint, $\pi_T = 0$, which is satisfied if the bank pays them an interest rate equal to

$$R(s,h) = \frac{T - (1-p)sh}{pT} \tag{2.10}$$

Using (2.10), the bank maximizes its profit by determining s and h subject to a technical constraint, which yields the following optimization problem and derivatives:

$$\pi_B = \max_{s,h} \quad p(X-1)(1-h) - pT(R(s,h)-1) \qquad \text{s.t.: } 0 \le s,h \le 1 \tag{2.11}$$

$$\frac{\partial \pi_B}{\partial s} = -pT\overbrace{\frac{\partial R(s,h)}{\partial s}}^{(\le 0)} = (1-p)h \ge 0 \tag{2.12}$$

$$\frac{\partial \pi_B}{\partial h} = -p(X-1) - pT\underbrace{\frac{\partial R(s,h)}{\partial h}}_{(\le 0)} = -p(X-1) + (1-p)s < 0 \tag{2.13}$$

Naturally, its expected profit depends positively on project profitability X and the success probability p. Unless the bank holds zero HQLAs or creditor rights are zero respectively, wholesale financiers demand a lower interest rate when they enjoy comprehensive rights in case of a bank default and when they receive a certain pay-off h in the bad state, i.e. $\frac{\partial R(s,h)}{\partial s} = -\frac{(1-p)h}{pT} \le 0$ and $\frac{\partial R(s,h)}{\partial h} = -\frac{(1-p)s}{pT} \le 0$.[14] The bank

[14] Likewise Admati et al. (2013) argue that higher equity holdings decrease the required return on equity. Also note that $R(s,h)$ decreases in m since wholesale creditors then manage to extract their

therefore optimally grants full creditor rights, i.e. $s = 1$, to wholesale financiers for $h > 0$ and is indifferent between all $s \in [0,1]$ otherwise; hence $\frac{\partial \pi_B}{\partial s} \geq 0$. The sign of the derivative with respect to the bank's profit is not clear for HQLA holdings h, which trigger two countervailing effects: First, the bank loses profits as it forgoes more profitable projects if it holds HQLAs instead, i.e. $\frac{\partial p(X-1)(1-h)}{\partial h} = -p(X-1) < 0$. Second, it benefits because wholesale creditors tend to demand a lower interest rate since they benefit from a more steady flow of payments, i.e. $\frac{\partial R(s,h)}{\partial h} \leq 0$. As a consequence, the bank chooses $h = 0$ whenever forgone investment profits due to a constraint outweigh the lower funding costs in expectation; similar trade-offs have been highlighted by Tirole (2011), Heider et al. (2015) and Tarullo (2014). $\frac{\partial \pi_B}{\partial h} < 0$ holds when $\frac{\partial p(X-1)(1-h)}{\partial h} > \frac{\partial pT(R(s,h)-1)}{\partial h}$.

Assumption 2. *The analysis thus subsequently focuses on the case in which the profitability of risky assets is sufficiently high, i.e.* $X > X^C = 1 - T\frac{\partial R(s,h)}{\partial h}$ *or* $X > X^C = 1 + \frac{(1-p)s}{p}$.

$\frac{\partial \pi_B}{\partial s} \geq 0$ is due to the fact that depositors do not react to contractual changes but wholesale financiers do $\left(\frac{\partial R(s,h)}{\partial s} \leq 0\right)$ if $h > 0$. Since $h = 0$, i.e. since the bank holds no HQLAs due to assumption 2, however, the share of the liquidation value it attributes to non-depositors is irrelevant. The bank therefore chooses $s \in [0,1], h = 0$.

Deposit insurer

Looking at the *deposit insurer's* expected obligations towards depositors, i.e. π_S (2.9), reveals that the probability of bailouts does not depend on s or h at all. Depositors definitely have to be bailed-out with probability $1 - p$. The available funds for the deposit insurer that are generated from the bank's liquidation, however, change: For $s = 1$ all liquidation proceeds goes to short-term wholesale financiers; similarly, for $h = 0$, the liquidation value is zero anyway. For $s = 1, h = 0$, for example, the deposit insurer (i.e. the public) therefore would have to bear all the bail-out costs, which amount to $(1-p)(1-T)$ in expectation. These negative effects of high creditor rights and low HQLA holdings on the deposit insurer are documented by the following two derivatives:

$$\frac{\partial \pi_S}{\partial s} = -\ (1-p)h \leq 0 \tag{2.14}$$

$$\frac{\partial \pi_S}{\partial h} = (1-p)(1-s) \geq 0 \tag{2.15}$$

Proposition 1. *The bank is indifferent with regard to the creditor rights it grants to its wholesale financiers and holds zero HQLAs, i.e.* $s \in [0,1]$ *and* $h = 0$. *Short-term creditors and depositors make zero expected profits. The latter are bailed-out if the bank defaults, i.e. with probability* $(1-p)$. *For* $h = 0$, *there is no liquidation value that can be split between short-term creditors and depositors; the deposit insurer bears the bail-out costs if the bank*

share of the liquidation value in the intermediate period, which is higher than the one at date 2, relatively often.

defaults, $(1-p)(1-T)$, and thereby implicitly subsidizes the bank, which can refinance itself cheaply and invests all funds into risky, profitable projects. Total welfare equals $\pi = pX - 1$, the sum of (2.6), (2.7), (2.8), and (2.9).

The bank is thus the only agent to earn positive expected profits (2.11). Those are generated by the yield on risky investments $p(X-1)(1-h)$ and the profit margin on short-term funds $p(X - R(s,h))$ as well as deposits $p(X-1)$. Deposit funding is especially advantageous. This is because deposit insurance induces depositors to charge an interest rate $R_D = 1$ instead of the higher $R(s,h)$ as imposed by short-term wholesale financiers. The difference constitutes an implicit subsidy of size $(1-T)(R(s,h)-1)$, which materializes with probability p for the bank, and which is provided by the deposit insurer. In other words, the bank benefits particularly from taking on deposits, for which the insurer provides a costly bail-out in the bad state, but not as much from accepting funds from wholesale creditors, who charge an interest rate in accordance with the associated risks. Note that, when $h > 0$, strong creditor rights would additionally decrease the minimum profitability X^C of the investment projects for which the bank takes on short-term debt. Also note that s in proposition 1 is a corner solution for $h > 0$, since the bank's profit derivative $\frac{\partial \pi_B}{\partial s}$ (2.12) is then always positive, which indicates that it would even choose $s > 1$ if it was technically possible. This is a result of the distortion which the presence of deposit insurance and limited liability impose on the bank's choice, i.e. the fact that the bank fails to account for the impact of its decisions on the deposit insurer's bail-out costs (i.e. $\frac{\partial \pi_S}{\partial s} < 0$ (2.14)).

2.4.2 First-best

The *regulator* may choose to constrain the set of the bank's choices with regard to s and h in order to maximize aggregate welfare as stated in (2.5). Differentiating the latter with respect to s and h, however, shows that

$$\frac{\partial \pi}{\partial s} = 0 \tag{2.16}$$

$$\frac{\partial \pi}{\partial h} = -pX + 1 < 0 \tag{2.17}$$

i.e. that the regulator is indifferent when it comes to the level of creditor rights and that he does not impose any HQLA requirements. These two derivatives could also be obtained by adding up the sensitivities of the bank and the regulator, i.e. equations (2.12) and (2.14) or equations (2.13) and (2.15) respectively: Limits on creditor rights provide no social value at all when $h = 0$ – and would merely redistribute welfare from the bank to the deposit insurer if h would be larger than zero; HQLA requirements, however, come at a loss of total welfare since the negative term in (2.17), which reflects the expected loss due to foregone investment opportunities for each unit of h the bank has to hold as a fraction of its assets, outweighs the benefit from enjoying a secure pay-off, h, in all states of the world.

Proposition 2. *The social optimum is compatible with the market outcome as shown in proposition 1; hence,* $s \in [0,1]$ *and* $h = 0$*; welfare equals* $\pi = pX - 1$*.*

The intuition for proposition 2 is straightforward: In the absence of new information, the bank is never liquidated in the intermediate period. Regulation therefore does not prevent any inefficiencies; but HQLA holdings would reduce welfare overall.

2.5 The case with the signal

Information updates about the state of banks, however, are omnipresent in reality. In fact, the stream of financial news produced by rating agencies, supervisory authorities, capital market specialists and newspapers is immense. A structured discussion of such updates' consequences for the funding stability of banks and overall economic welfare is thus vital for a qualified assessment of the regulatory options at hand, which is especially so in view of the financing behavior European banks had been engaging in during the run-up to the crisis. As it turns out, the presence of the noisy signal may trigger withdrawals from wholesale financiers. These may be socially inefficient as they destroy economic welfare and may be prevented by appropriate regulatory measures.

THE SIGNAL: This analysis introduces such signals as follows: The information update concerns the quality of the bank's risky projects, is freely available, and arrives at date 1. It may either deliver positive news with probability p or negative ones with probability $(1-p)$. Following Huang and Ratnovski (2011), the update is noisy and arrives with expected quality $\theta \in [0,1]$ where $\theta = 0$ indicates complete noise and $\theta = 1$ total precision; θ may be interpreted as the most precise update out of a stream of updates. The signal can be read by short-term wholesale financiers but not by normal retail depositors. Conditional on a positive signal, the date 2 success probability of the bank's risky projects rises to $p + \theta(1-p)$ while the probability of failure falls to $(1-p) - \theta(1-p)$; see column 2 in table 2.1. A negative signal, on the other hand, reduces the former to $p - \theta p$ and lifts the latter to $(1-p) + \theta p$, respectively; see column 3 in table 2.1. The timeline in figure 2.3 summarizes the timing and highlights the changes due to the signal in bold letters.

2.5.1 Market equilibrium

Short-term wholesale financiers

IMPACT ON ROLL-OVER AND THE PAY-OFF FUNCTION π_T: The considerations of wholesale financiers remain similar to those in the benchmark scenario; they either

Realization of risky projects	pos. update (prob. p)	neg. update (prob. $1-p$)	Σ
X	$p+\theta(1-p)$	$(1-\theta)p$	p
0	$(1-p)(1-\theta)$	$(1-p)+\theta p$	$(1-p)$
Σ	1	1	1

TABLE 2.1: Probabilities conditional on noisy market update

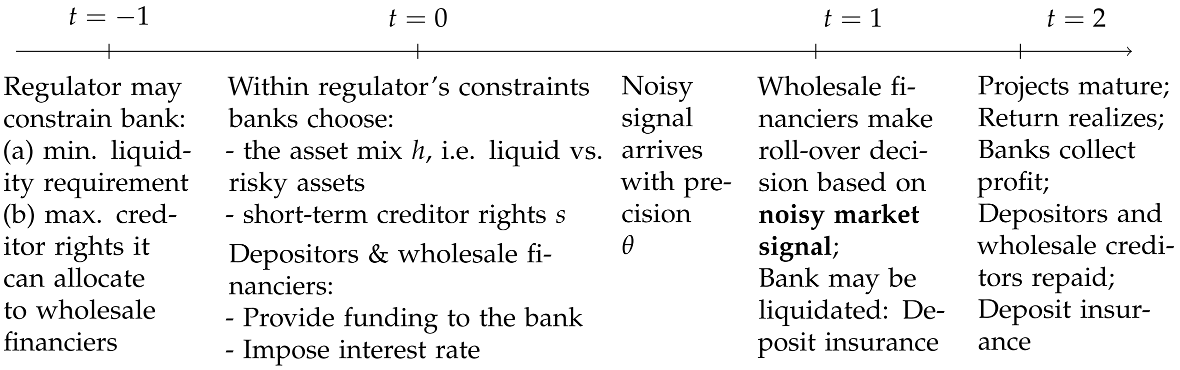


FIGURE 2.3: Timeline with market signal

receive TR if the bank survives beyond the final period or sh if it defaults at date 2. However, wholesale financiers now anticipate at date 0 that they will receive an update with precision θ at the beginning of date 1, which changes the probabilities according to table 2.1 above. Their expected pay-off function from the viewpoint of date 0 therefore has to be deduced as follows: For positive updates, which arrive with probability p, they receive $TR(s,h)$ with the updated probability $p+\theta(1-p)$ or sh with probability $(1-p)(1-\theta)$ at date 2; for negative updates, on the other hand, which arrive with probability $1-p$, the wholesale financiers' expected pay-off equals $TR(s,h)$ with the reduced probability $[p-\theta p]$ or sh with probability $(1-p)+\theta p$:

$$\begin{aligned} \pi_T &= \Big[p\Big([p+\theta(1-p)]TR+(1-p)(1-\theta)sh\Big) \\ &+ \underbrace{(1-p)}_{\substack{\text{probability of receiving}\\ \text{negative signal}}} \Big(\underbrace{[p-\theta p]TR+[(1-p)+\theta p]sh}_{\substack{\text{Expected date 2 pay-off}\\ \text{after a negative update}}}\Big)\Big]-T \end{aligned} \tag{2.18}$$

Naturally, a positive market signal lifts the likelihood for full interest rate repayments from p to $p+\theta(1-p)$ and therefore does not change their decision; they keep their money with the bank. A negative one, which may, for instance, occur during a recession, however, may do so: In this case, wholesale financiers withdraw their funding based on such an update – and thereby trigger liquidation – whenever this is beneficial for themselves, i.e. whenever

$$\pi_T^W = \Big[p\Big([p+\theta(1-p)]TR+(1-p)(1-\theta)sh\Big)$$

$$+(1-p) \quad \underbrace{s[(1-h)L+h]}_{\substack{\text{Date 1 pay-off if wholesale financiers} \\ \text{liquidate after a negative signal}}} \Big] - T \tag{2.19}$$

is larger than π_T (2.18). This is the case whenever their part of the bank's liquidation value at date 1 – which is underbraced in π_T^W and which is certain at date 1 – is higher than their expected date 2 pay-off with the updated success probabilites, which is underbraced in π_T, i.e. when

$$s[(1-h)L+h] > (1-\theta)pTR + [(1-p)+\theta p]sh \tag{2.20}$$

TWO CASES: Depending on whether condition (2.20) is fulfilled or not, two cases must be differentiated: While wholesale creditors roll-over even for negative updates if it does not hold (**roll-over case**), they withdraw if it does (**withdrawal case**). In the **roll-over case**, their expected welfare function, as shown in (2.18), collapses back to the same one as in the case without an update, i.e.

$$\pi_T^R \quad = \quad pTR + (1-p)sh - T \tag{2.21}$$

In the **withdrawal case**, the bank survives less often as shown by the first term in (2.22) below. This can be easily computed by deducting $(1-p)(p-\theta p)$ in (2.18), i.e. the probability of a negative signal multiplied by the survival probability upon receiving it which drops out if wholesale financiers withdraw (see (2.19)), from p, i.e. the survival probability in the roll-over case. Hence, they face welfare function (2.19) which collapses to

$$\pi_T^W \quad = \quad \underbrace{p\Big[1-(1-p)(1-\theta)\Big]}_{=p-(1-p)(p-\theta p)} TR + (1-p)s\Big[(1-h)L+h+p(1-\theta)h\Big] - T \tag{2.22}$$

Bank

The bank designs a contract for both cases and selects the one which generates a higher profit in expectation. For that purpose it sets wholesale creditor rights s, chooses its HQLA holdings h, and offers an interest rate R. The two scenarios may be characterized as follows: **Roll-over case:** In the roll-over case, the bank survives with probability p. It obviously has no incentive to pay wholesale financiers an interest rate above their participation constraint $\pi_T^R = 0$. The interest rate $R^R(s,h)$ therefore looks as follows:

$$R^R(s,h) \quad = \quad \frac{T-(1-p)sh}{pT} \tag{2.23}$$

It is the exact same interest rate as in the benchmark case in (2.10). Apart from choosing this lowest possible interest rate $R^R(s,h)$ the bank also decides on the level of creditor rights s it grants to its wholesale financiers and the volume of HQLAs h it holds. In order to guarantee that wholesale creditors renew their funding in the intermediate period, however, s and h must be chosen in such a way that condition (2.20) holds with reversed sign, i.e. such that $s[(1-h)L+h] \leq (1-\theta)pTR + [(1-p)+\theta p]sh$, which can be rearranged to yield a level of creditor rights s below a threshold value $\bar{s}$, i.e. $s \leq \bar{s} = \frac{(1-\theta)pTR^R(s,h)}{(1-h)L+ph(1-\theta)}$. Using the analytical expression $R^R(s,h) = \frac{T-(1-p)sh}{pT}$ and solving for s yields $\bar{s}$ as a function of parameters. The bank's maximization problem therefore presents itself as follows:

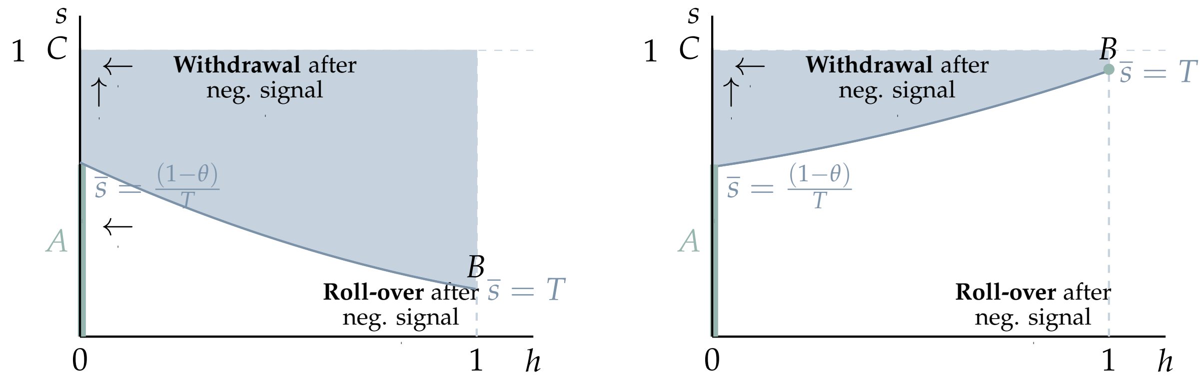
$$\pi_B^R = \max_{s,h} \quad p\Bigg[\underbrace{(X-1)(1-h)}_{\substack{\text{profits on}\\ \text{risky projects}}} - \underbrace{T\Bigg(\overbrace{\frac{T-(1-p)sh}{pT}}^{R^R(s,h)} - 1\Bigg)}_{\substack{\text{funding costs paid}\\ \text{to wholesale financiers}}}\Bigg] \tag{2.24}$$

$$s.t.: \quad s \leq \bar{s} = \frac{(1-\theta)T}{(1-h)L+h(1-\theta)}$$

The solution of this problem is rather involved and therefore discussed extensively in section 2.B of the appendix. The steps presented there show that the bank sets creditor rights, s, as high as it is compatible with the constraint $s \leq \bar{s}$, unless h equals zero in which case the bank is indifferent between all levels of $s \in [0, \bar{s}]$, as shown by the green lines marked A at the ordinate in figures 2.4 (A) and (B). This is true because wholesale creditors demand a lower interest rate when they receive a large share of the liquidation value s of the bank's positive level of HQLAs, which provide a pay-off $h > 0$ even if the bank defaults. Whenever $h = 0$, there is no liquidation value at date 2 which is why creditor rights s have no impact on the bank's refinancing rate. Furthermore, the solution demonstrates that – for the same reasons as in the benchmark case discussed above – the bank is likely to hold no HQLAs, since doing so implies foregone investment profits of risky projects that outweigh the funding cost benefit.

Figure 2.4, however, illustrates that HQLA holdings exert a third effect, which has not played a role in the benchmark scenario, i.e. their impact on maximum creditor rights consistent with the roll-over regime, $\frac{d\bar{s}}{dh}$. $\frac{d\bar{s}}{dh}$ is negative if the liquidation value is rather small, i.e. if $L < (1-\theta)$, as exemplified by the downward sloping line in figure 2.4 (A); in this case the bank's preference not to hold HQLAs is further reinforced as HQLA holdings would then not only cause opportunity costs but would even incentivize wholesale financiers to run; this is because HQLAs, which can be sold without loss at any time, then push up the (otherwise small) date 1 liquidation value for wholesale creditors particularly strongly in relative terms (from sL to $sL + sh[1-L]$) – more than they raise their expected date 2 pay-off, which does not depend on L. $\frac{d\bar{s}}{dh}$ is, however, positive if $L > (1-\theta)$, as in figure 2.4 (B). Due to this possible positive effect of HQLA holdings on the threshold $\bar{s}$ it is (in principle) possible that the bank decides to build up such a buffer.

(A) Bank always chooses A (B) Bank chooses A or B



The figures show the threshold for creditor rights $\bar{s}$ as a function of HQLA holdings h. Creditor rights must be tighter if the bank holds more HQLAs in the left-hand graph and can be relaxed if the bank holds more HQLAs in the right-hand graph. Short-term wholesale financiers liquidate in the shaded area and roll-over otherwise. (A) represents a scenario in which $s = \bar{s}$ is implemented by constraining creditor rights to $s = \bar{s} = (1-\theta)/T$ rather than holding HQLAs, while (B) corresponds to a case in which wholesale financiers can enjoy higher creditor rights $s = \bar{s} = T$ because the bank invests in HQLAs to the amount of $h = 1$.

FIGURE 2.4: Two cases: withdrawal vs. roll-over

CHOICE BETWEEN TWO OPTIONS: The bank's objective function is convex in h. If $\frac{d\bar{s}}{dh}$ is positive, its profit-maximizing choice thus ultimately boils down to deciding between two options: $s \in [0, \bar{s}], h = 0$ (line A in figure 2.4 (B)) and $s = \bar{s}, h = 1$ (point B), i.e.

$$\pi_B^R = \max\Big\{\underbrace{\pi_B^R(s \in [0,\bar{s}], h = 0)}_{\text{roll-over due to limit on creditor rights}},\ \underbrace{\pi_B^R(s = \bar{s}, h = 1)}_{\text{roll-over due to HQLA requirements}}\Big\} \tag{2.25}$$

Note that $\bar{s} = \frac{(1-\theta)T}{L}$ in the former and $\bar{s} = T$ in the latter case. One can easily compare its profit for these two possibilities, which demonstrates that the bank always chooses creditor rights limits only (i.e. to never hold HQLAs) to implement $\bar{s}$ because it is always true that:

$$\overbrace{p\left[X - 1 - T\left(\underbrace{\frac{1}{p}}_{R^R(s\in[0,\bar{s}],h=0)} - 1\right)\right]}^{\text{Bank profit } \pi_B^R(s\in[0,\bar{s}],h=0)} > \overbrace{p\left[X - 1 \underbrace{-(X-1)}_{\text{foregone profits on risky projects}} - T\left(\underbrace{\frac{T-(1-p)T}{pT}}_{R^R(s=\bar{s},h=1)\text{: lower wholesale funding costs}} - 1\right)\right]}^{\text{Bank profit } \pi_B^R(s=\bar{s},h=1)}$$

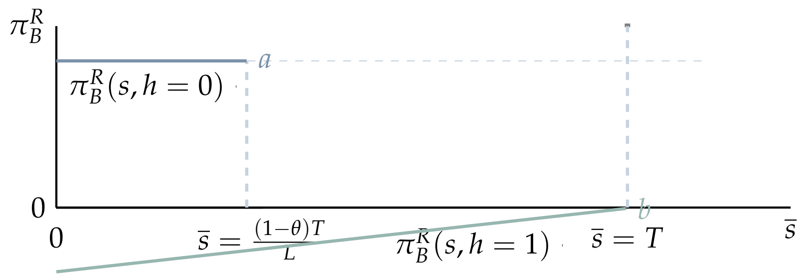
$$p\left[X - 1 - T\left(\frac{1}{p} - 1\right)\right] > 0 \tag{2.26}$$

The bank's profit in the $s = \bar{s}, h = 1$–scenario equals zero (when it sets wholesale creditor rights to the maximum, i.e. $s = T$) and is positive in the $s \in [0, \bar{s}], h = 0$ case. Intuitively, this is the case because the lower funding costs that come with holding

HQLAs cannot make up for the lost investment profits. Figure 2.5 also depicts the choice between $s \in [0, \bar{s}], h = 0$ (point a) and $s = \bar{s}, h = 1$ (point b when $s = T$). Note that the bank's profit as a function of creditor rights s – when $h = 0$ – is a horizontal line since s has no effect on the refinancing rate, and therefore also not on the bank's profit. For the same reasoning, its profit as a function of creditor rights s – when $h = 1$ – is upward sloping; wholesale creditors charge a lower interest rate if they receive a larger share s of the positive liquidation value. Since the bank always chooses $h = 0$ the critical threshold for creditor rights referred to hereafter equals

$$\bar{s} = \frac{(1-\theta)T}{L}. \tag{2.27}$$

The latter makes sense from an intuitive perspective: After all, $\frac{\partial \bar{s}}{\partial L} < 0$ means that the creditor rights constraint, $\bar{s}$, may be relatively relaxed (i.e. high) whenever the liquidation value of the bank's risky projects is low; this implies that a withdrawal is generally less attractive for wholesale financiers if the bank is a relationship-lender and therefore possesses intimate knowledge about its client portfolio, the latter of which may be partially lost by transferring the bank's distressed loan portfolio to potential buyers. $\frac{\partial \bar{s}}{\partial T} > 0$, on the other hand, is an immediate consequence of the contractual design and states that creditor rights must be tightened when T is small; deposits, $1 - T$, then provide a sizeable buffer for the liquidation losses, $1 - L$, which incentivizes wholesale creditors to refuse roll-over and impose losses on the depositors.



The figure shows bank profit as a function of wholesale creditor rights s within the roll-over regime for which the bank chooses a combination of s and h such that the constraint $\bar{s}$ is just fulfilled. It depicts profits for a constant level of $h = 0$ (blue line) and $h = 1$ (green line) respectively. There are no liquidations based on noisy negative signals. Since $a > b$ the bank implements $s = \bar{s}$ by setting $s \in [0, \bar{s}], h = 0$ rather than $s = \bar{s}, h = 1$.

FIGURE 2.5: Bank profit in the roll-over regime

Lemma 1. *In order to stay in the roll-over case, i.e. to guarantee stable funding from its wholesale financiers, even in the presence of negative market updates, the bank has to fulfil the constraint $s \leq \bar{s}$. It does so by choosing $s \in [0, \bar{s}], h = 0$, i.e. A in figure 2.4. The maximum level of wholesale creditor rights $\bar{s}$ consistent with the roll-over regime is relatively low if the bank is funded mostly by deposits, $\frac{\partial \bar{s}}{\partial T} > 0$, and comparatively high if the bank is a relationship lender, $\frac{\partial \bar{s}}{\partial L} < 0$.*

Withdrawal case: In the withdrawal case the bank survives only with probability

$p[1-(1-\theta)(1-p)$. It obviously has no interest in paying wholesale financiers an interest above their participation constraint. The interest rate $R^W(s,h)$ the bank pays is different from $R^R(s,h)$ and can be derived from the zero-profit condition $\pi_T^W = 0$:

$$R^W(s,h) = \frac{T-(1-p)s\Big[(1-h)L+h+p(1-\theta)h\Big]}{pT\Big[1-(1-\theta)(1-p)\Big]} \tag{2.28}$$

Apart from choosing this lowest possible interest rate $R^R(s,h)$ the bank also decides about the creditor rights s it grants to its wholesale financiers and the volume of HQLAs h it holds. This time, it chooses the two variables such that condition (2.20) holds, i.e. such that $s[(1-h)L+h] > (1-\theta)pTR + [(1-p)+\theta p]sh$, which can be rearranged to yield $s > \bar{s} = \frac{(1-\theta)[T-(1-p)sh]}{(1-h)L+ph(1-\theta)}$. The combination of s and h is therefore in the blue shaded area of figure 2.4; wholesale financiers then refuse to renew their funding to the bank for negative updates in the intermediate period. Using the analytical expression for $R^W(s,h)$ the bank's maximization problem consequently presents itself as follows:

$$\begin{aligned}\pi_B^W = \max_{s,h} \quad & \overbrace{p\Big[1-(1-\theta)(1-p)\Big]}^{\text{reduced survival probability}}\Big[\overbrace{(X-1)(1-h)}^{\text{profits on risky projects}} \\ & \underbrace{-T\Bigg(\overbrace{\frac{T-(1-p)s[(1-h)L+h+p(1-\theta)h]}{pT[1-(1-\theta)(1-p)]}}^{R^W(s,h)}-1\Bigg)\Big]}_{\text{funding costs paid to wholesale financiers}}\end{aligned} \tag{2.29}$$

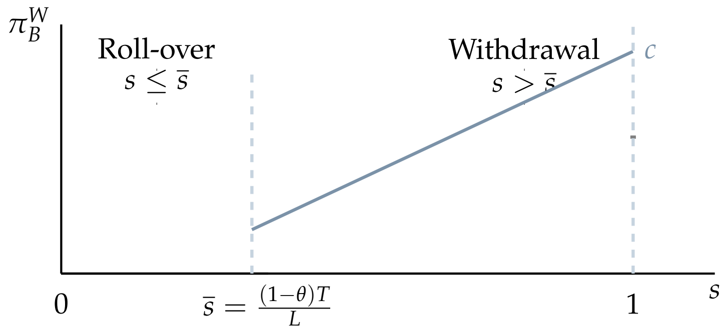
$$s.t.: \quad s > \bar{s}$$

Within the 'withdrawal' regime, it is straightforward to show that the bank offers maximum creditor rights and holds no HQLAs:

$$\frac{\partial \pi_B^W}{\partial s} = \overbrace{(1-p)\Big[(1-h)L+h+p(1-\theta)h\Big]}^{\text{Refinancing cost decrease in } s} > 0 \tag{2.30}$$

$$\frac{\partial \pi_B^W}{\partial h} = \underbrace{-p\Big[1-(1-\theta)(1-p)\Big](X-1)+(1-p)s\Big[1-L+p(1-\theta)\Big]}_{\text{Foregone investment profit outweighs lower refinancing cost}} < 0 \tag{2.31}$$

The signs of these derivatives mean that, within the blue shaded area in figure 2.4, the bank chooses point C, i.e. $s=1$ and $h=0$. They also imply that the bank's profit unambiguously increases in the creditor rights s that it allocates to its wholesale financiers; and that it decreases in h if HQLAs come at sufficiently high opportunity costs, $X > X^C = 1 + \frac{(1-p)s[1-L+p(1-\theta)]}{p[1-(1-\theta)(1-p)]}$. Figure 2.6 highlights the positive impact of more generous creditor rights s on the bank's profit, i.e. $\frac{\partial \pi_B^W}{\partial s} > 0$, by the upward-sloping blue line. The slope of the latter equals $\frac{\partial \pi_B^W}{\partial s} = (1-p)L$ for $h = 0$. Intuitively, it is upward sloping because, when the threshold $\bar{s}$ is violated, there is a positive probability of bank liquidations at date 1. Since the liquidation value, $L > 0$, which is recovered after such liquidations, is split between retail depositors and wholesale financiers strong creditor rights have value for wholesale financiers, whose required interest rate therefore decreases, which, in turn, implies that the bank's profit increases.



The figure shows the bank's profit for $s > \bar{s}$ as a function of short-term wholesale financiers' creditor rights s for a constant level of $h = 0$.

FIGURE 2.6: Bank profit in the withdrawal regime

Lemma 2. *Within the withdrawal case, i.e. when $s > \bar{s}$ such that wholesale financiers withdraw for negative updates, the bank chooses to give them as generous rights as possible and to hold no HQLAs, i.e. $s = 1, h = 0$ – point C in figure 2.4 or c in figure 2.6.*

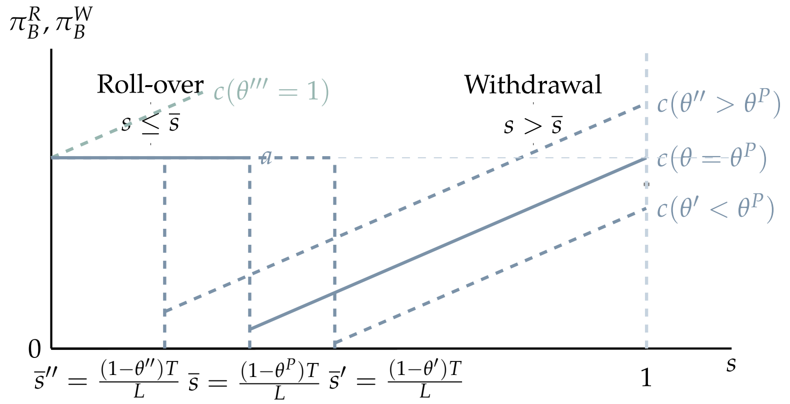
The bank's choice between the roll-over regime and the withdrawal regime

Since it has now been established that the bank chooses $s \in [0, \bar{s}], h = 0$ in the roll-over regime and $s = 1, h = 0$ within the withdrawal scenario, one can now complete its reasoning, i.e. investigate its decision between the two regimes:

$$\pi_B = \max\Big\{\underbrace{\pi_B^R(s \in [0,\bar{s}], h = 0)}_{\text{Profit in roll-over case}},\ \underbrace{\pi_B^W(s = 1, h = 0)}_{\text{Profit in withdrawal case}}\Big\} \tag{2.32}$$

This is illustrated in figure 2.7, where the horizontal blue line in the domain left of $\bar{s}$ and the upward sloping blue line right of $\bar{s}$ correspond to the ones in figure 2.5 and 2.6 respectively.

The discrete drop of the bank's expected profit when it just slightly exceeds the threshold $\bar{s}$ comes from the sudden transition from the 'roll-over' regime to the 'withdrawal' regime. The magnitude of the drop can be derived by deducting π_B^R (2.24)



The figure shows bank profit as a function of wholesale financier's creditor rights for a level of $h = 0$. For values of s equal to or smaller than $\bar{s}$ there are no liquidations based on the noisy signal. For s larger than $\bar{s}$ this no longer holds (discrete drop at $\bar{s}$). For $c > a$, however, the bank gains from violating this limit and setting $s = 1$. While the upward-sloping blue line depicts the bank's profit function for a level of θ for which the bank is just indifferent between c and a, the dashed lines show that function for different precision levels.

FIGURE 2.7: Bank profit for different precision levels of the market signal

from π_B^W (2.29) at $s = \bar{s}, h = 0$ which yields:[15]

$$\pi_B^W - \pi_B^R \quad = \quad -p(1-p)(1-\theta)\left[\left(X-1\right) - T\left(\frac{1}{p}-1\right)\right] < 0 \tag{2.34}$$

(2.34) reflects the consequences of the bank's reduced survival probability, i.e. that it gets profits from risky projects less often but also pays the interest rate to wholesale financiers less frequently. At $\bar{s}$ the bank's profit with withdrawals is lower than the one without because the lost expected profit from the risky projects dominate the more favorable funding terms. After the drop at $\bar{s}$, however, the bank benefits from choosing higher levels of s due to $\frac{\partial R^W(s,h)}{\partial s} < 0$. Ultimately, the bank compares points a to c in figure 2.7 and chooses to violate the $\bar{s}$ threshold whenever π_B^W(2.29) evaluated at $s = 1, h = 0$ is higher than π_B^R(2.24) evaluated at $s = \bar{s}, h = 0$, i.e. whenever:

$$\begin{aligned}\pi_B^W - \pi_B^R \quad = \quad & -p(1-\theta)(1-p)\left[(X-1)\right] \\ & +pT\left[R^R(s=\bar{s}, h=0) - R^W(s=1, h=0)\right] \\ & +pT(1-\theta)(1-p)\left[(R^W(s=1, h=0)-1)\right] > 0\end{aligned} \tag{2.35}$$

CHOICE DEPENDS ON SIGNAL'S PRECISION: The bank therefore favors c over a

15

$$\text{Full expression: } \pi_B^W - \pi_B^R \quad = \quad \underbrace{\overbrace{-p(1-\theta)(1-p)\left[(X-1)\right]}^{\text{Bank gets return less often if liqu.}} \overbrace{+pT\left[R^R(s=\bar{s}, h=0) - R^W(s=\bar{s}, h=0)\right]}^{\text{pays a diff. interest rate}} \\ +pT(1-\theta)(1-p)\left[(R^W(s=\bar{s}, h=0)-1)\right]}_{\text{pays the interest rate less often}} < 0 \tag{2.33}$$

if the funding cost benefit that comes with generous creditor rights, $s \geq \bar{s}$, (line 2 and 3 in (2.35)), dominates the lost investment profits, which are due to its lower survival probability (line 1). Using the analytical expressions for $R^R(s,h)$ (2.23) at $s = \bar{s}, h = 0$ and $R^W(s,h)$ (2.28) at $s = 1, h = 0$, it can be shown that condition (2.35) is satisfied, i.e that the bank chooses the withdrawal case $s > \bar{s}$, whenever the signal is sufficiently precise, i.e. when it arrives with a quality level:

$$\theta > \theta^P = 1 - \frac{L}{p[X - 1 + T]} \tag{2.36}$$

This means that point $c(\theta = \theta^P)$ is just equal to a in figure 2.7. The effect of the update's precision is illustrated by the vertical shifts of the blue lines in the domain(s) right of $\bar{s}$. Intuitively, the bank favors the violation of the threshold $\bar{s}$ for the following reasons: Withdrawals upon a noisy market signal gain attractiveness for wholesale financiers when this signal is rather precise. Avoiding these withdrawals thus requires comparatively stronger restrictions, i.e. $\bar{s}'' < \bar{s}$. At the same time, however, the slope of the profit function below and above the threshold value $\bar{s}$ remains unchanged, i.e. $\frac{\partial \pi_B^R}{\partial s} = 0$ and $\frac{\partial \pi_B^W}{\partial s} = (1-p)L > 0$ respectively, while the drop of the bank's profit at $\bar{s}''$ shrinks in θ as expressed in (2.34); for $\theta > \theta^P$ the bank therefore prefers the withdrawal case.[16]

Lemma 3. *Whenever the market signal is sufficiently precise, i.e. whenever $\theta > \theta^P$, the bank chooses maximum creditor rights, $s = 1$, and minimum HQLA holdings, $h = 0$, at date 0 and willingly accepts the increased funding instability, i.e. the probability of liquidations based on noisy market updates at date 1, that comes with this decision.*

Lemma 3 emerges because the bank does not forego any profitable investments when it holds zero HQLAs and because it benefits from favorable refinancing conditions when wholesale creditor rights are strong. Whenever $\theta > \theta^P$, these expected benefits outweigh the expected profit loss due to the heightened default probability. The bank's choice of $s = 1$, $h = 0$, however, is based on two questionable considerations: First, the funding cost advantage that comes with $s > \bar{s}$ is a private benefit for the bank. Second, the bank is protected by limited liability and ignores expected bail-out costs. Put differently, the bank's choice to favor a over b may impose costs on other agents.

Depositors

Although *depositors*, who are unable to interpret the market signal, receive their money back from the bank less frequently in the update's presence if the bank chooses $s \geq \bar{s}$

16 In the extreme case of a fully precise free market signal, i.e. $\theta = 1$, terms one, two and three in (2.35) would become zero (the expressions for $R^R(s,h)$ and $R^W(s,h)$ are then analytically exactly the same). Such a profit function would be linearly increasing without jumps and would start at level a for $s = 0$ as shown by the green dashed line in figure 2.7. It would thus dominate all other possible profit functions for the bank for all values of s; the bank would consequently clearly benefit from the existence of such a precise market signal and would always choose $s = 1, h = 0$.

(**withdrawal case**) rather than $s \leq \bar{s}$ (**roll-over case**), deposit insurance means that their expected pay-off is the same in both regimes:

$$\pi_D^R = p(1-T) + (1-p)(1-T) - (1-T) = 0 \tag{2.37}$$

$$\begin{aligned}\pi_D^W &= \overbrace{p\Big[1-(1-\theta)(1-p)\Big](1-T)}^{\text{receive deposits back from bank less often}} + \\ &\underbrace{\Big(1-p\Big[1-(1-\theta)(1-p)\Big]\Big)(1-T)}_{\text{receive deposits back from insurer more often}} - (1-T) = 0\end{aligned} \tag{2.38}$$

Deposit insurer

Roll-over case: The *deposit insurer* bails out depositors with probability $(1-p)$ when wholesale creditor rights are limited to $s \leq \bar{s}$. It can, for $h > 0$, then partially cover its obligations with the proceeds from the bank's liquidation. Its pay-off function and the relevant derivatives therefore are as follows:

$$\pi_S^R = -\overbrace{(1-p)}^{\substack{\text{probability for}\\ \text{deposit insurance}}}(1-T) + \overbrace{(1-p)(1-s)h}^{\substack{\text{Obtains a liquidation value}\\ (1-s)h \text{ at date 2}}} \tag{2.39}$$

$$\frac{\partial \pi_S^R}{\partial s} = -(1-p)h \leq 0 \tag{2.40}$$

$$\frac{\partial \pi_S^R}{\partial h} = (1-p)(1-s) \geq 0 \tag{2.41}$$

For $h = 0$, as chosen by the bank, it is irrelevant for the deposit insurer where creditor rights are in the interval $s \in [0, \bar{s}]$. This is depicted by the horizontal gray line in negative territory in figure 2.8.

Withdrawal case: If the bank chooses $s \geq \bar{s}$, however, the deposit insurer has to intervene in order to bail-out depositors relatively often, i.e. with probability $1 - p\big[1 - (1-\theta)(1-p)\big]$ – see (2.22) for an intuitive explanation of the term $p\big[1-(1-\theta)(1-p)\big]$ – rather than $1-p$ as in (2.39). Its pay-off function and derivatives consequently are as follows

$$\begin{aligned}\pi_S^W &= -\overbrace{\Big(1-p\Big[1-(1-\theta)(1-p)\Big]\Big)}^{\text{must provide deposit insurance more often}}(1-T) \\ &\underbrace{+(1-p)(1-s)\Big[(1-h)L + h + p(1-\theta)h\Big]}_{\text{can use its share of the liquidation value at date 1, i.e. (1-h)L + h, or date 2, i.e. h, to partially cover it}}\end{aligned} \tag{2.42}$$

$$\frac{\partial \pi_S^W}{\partial s} = -(1-p)\Big[(1-h)L + h + p(1-\theta)h\Big] < 0 \tag{2.43}$$

$$\frac{\partial \pi_S^W}{\partial h} = (1-p)(1-s)\Big[1 - L + p(1-\theta)\Big] > 0 \tag{2.44}$$

whereby (2.43) equals (2.30) with opposite sign, which implies that, within the withdrawal regime, the bank's gain from granting generous creditor rights comes at a loss to the deposit insurer of equal size. The two sensitivities furthermore reveal that the deposit insurer's pay-off is at its lowest possible value when the bank chooses $s = 1$, $h = 0$. This is because the bail-out cannot be partially covered by the bank's liquidation value when s equals one, i.e. because line two in (2.42) then becomes zero.

At $s = 1$, $h = 0$ the deposit insurer's pay-off in the withdrawal case, π_S^W, thus clearly lies below the one in the roll-over case, π_S^R, since the bailout $1 - T$ has to be provided more often:

$$\pi_S^W(s = 1, h = 0) - \pi_S^R(s \in [0, \bar{s}], h = 0) \quad = \quad \underbrace{-p(1-\theta)(1-p)}_{\text{Bailout provided more often}}(1-T) \tag{2.45}$$

This difference is illustrated in figure 2.8. Only if the signal is fully precise, in which case withdrawals are not inefficient, does expression (2.45) become zero. At $\theta = \theta^P = 1 - \frac{L}{p[X-1+T]}$, however, i.e. the precision of the market update for which the bank's profit at $s = 1, h = 0$ just equals its profit in the roll-over regime, the deposit insurer's loss is clearly negative, i.e. $-(1-p)\frac{1-T}{X-1+T} < 0$. His expected pay-off as a function of s for the region $s > \bar{s}$ is shown by the downward sloping gray line in figure 2.8.[17]

Lemma 4. *The bank's choice to grant maximum creditor rights to wholesale financiers and to hold no HQLAs, i.e. $s = 1$, $h = 0$, implies that depositors must be bailed-out relatively frequently and that the entire liquidation value goes to the wholesale creditors.*

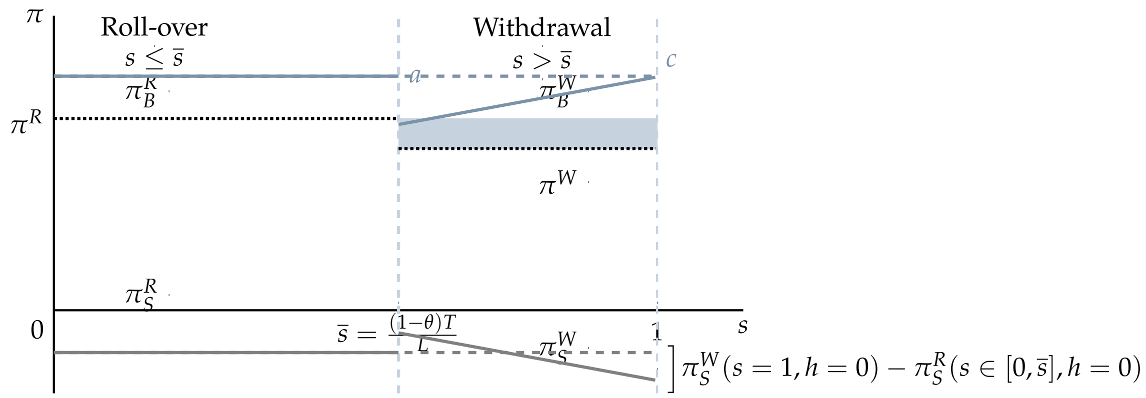
Aggregate market equilibrium:

Summing up over π_T^W (2.22), π_B^W (2.29), π_D^W (2.38), and π_S^W (2.42) yields aggregate welfare in the market equilibrium for the **withdrawal case** as shown in (2.47); the latter is illustrated by the black dotted line to the right of $\bar{s}$ in figure 2.8. The same function for the market equilibrium in the **roll-over case**, i.e. (2.46), which is represented by the black dotted line to the left of $\bar{s}$, may be derived by adding up π_T^R (2.21), π_B^R (2.24), π_D^R (2.37), and π_S^R (2.39):

$$\pi^R \quad = \quad p(1-h)X + h - 1 \tag{2.46}$$

$$\pi^W \quad = \quad p(1-h)X\Big[1 - (1-\theta)(1-p)\Big] + (1-p)(1-h)L + h - 1 \tag{2.47}$$

[17] The discontinuity at $\bar{s}$ is a drop if $\pi_S^W(s = \bar{s}, h = 0) - \pi_S^R(s \in [0, \bar{s}], h = 0) < 0$ and an increase (non-existent) otherwise; when the update is fully precise, for instance, the term $1 - p[1 - (1-\theta)(1-p)]$ in (2.42) transforms into $1 - p$; the difference in bail-out costs between the two regimes then becomes zero while the second term in (2.42), i.e. the deposit insurer's share of the liquidation value, remains positive in both regimes. The deposit insurer may then be better off in the withdrawal regime in which a rather large liquidation value materializes at date 1.



The figure shows bank profit π_B^R and π_B^W (blue lines) and the pay-off of the deposit insurer π_S^R and π_S^W (gray) depending on creditor rights for $h = 0$ and θ just above θ^P. It also depicts total welfare in both regimes, i.e. π^R and π^W (black dotted). Total welfare is the sum of the bank's and the regulator's pay-offs; for s larger than $\bar{s}$, liquidations based on the noisy signal occur; hence the discrete jumps at $\bar{s}$.

FIGURE 2.8: Welfare functions: Bank, deposit insurer, and total welfare

Subtracting the former from the latter for $h = 0$ yields:

$$\pi^W - \pi^R \;=\; -(1-p)\Big[\underbrace{p(1-\theta)X}_{\text{investment profits realize less often}} - \underbrace{L}_{\text{certain date 1}}\Big] \tag{2.48}$$

The sign of (2.48) obviously depends on the parameter constellations. At $\theta = \theta^P = 1 - \frac{L}{p[X-1+T]}$, i.e. the precision of the market signal for which the bank's profit at $s = 1, h = 0$ just equals its profit in the roll-over regime, however, it is clearly negative. The drop of aggregate welfare corresponds to $-(1-p)\frac{1-T}{X-1+T} < 0$. The latter is illustrated by the jump of the black dotted function at $\bar{s}$ in figure 2.8. It represents the overall-welfare loss in the market equilibrium when the bank chooses $s = 1, h = 0$ rather than $s \in [0, \bar{s}], h = 0$ when $\theta = \theta^P$.[18] As highlighted by the blue shaded area in figure 2.8 this overall drop is independent from the creditor rights level s, since the latter merely determines how welfare is distributed between the bank and the deposit insurer. At $s = 1$, for instance, the entire drop is borne by the deposit insurer as described for (2.45) above.

Interestingly, the expression $-(1-p)\frac{1-T}{X-1+T}$ furthermore implies that there are no social losses when the bank is entirely short-term funded, i.e. when $T = 1$, as there are then no depositors that have to be bailed-out. It also suggests that the bank's choice to set $s = 1, h = 0$ – and the wholesale financiers' agreement with it – is due to its ignorance of the bail-out costs its decision imposes on the deposit insurer, i.e. $\pi_S^W = -(1 - p[1-(1-\theta)(1-p)])(1-T)$. Unless $T = 1$, in which case π_S^W becomes zero, total welfare, π^W, therefore always lies below the bank's profit function.

[18] Losses may be even higher in reality given that liquidation may cause negative spillover effects to other parts of the economy, rising tax rates, rating downgrades, or capital misallocation due to distorted asset prices after central bank interventions. These effects would further strengthen the results.

INEFFICIENT REGION $\theta \in [\theta^P, \theta^C]$**:** Figure 2.9 depicts total welfare as a function of θ and shows that welfare in the domain $s > \bar{s}$, π^W, is increasing in the market signal's precision. The exact slope equals $\frac{\partial \pi^W}{\partial \theta} = p(1-h)X(1-p) > 0$. Hence, while a market signal with a precision just above θ^P reduces welfare due to the bank's choice of $s = 1, h = 0$ (as described above), very strong signals may actually do the opposite. This makes sense from an intuitive perspective: After all, the free availability of a very precise market update provides information that helps wholesale creditors to make better roll-over decisions in the intermediate period. The precision level of the signal above which this is actually the case can be derived by setting $\pi^W = \pi^R$ and solving for θ:

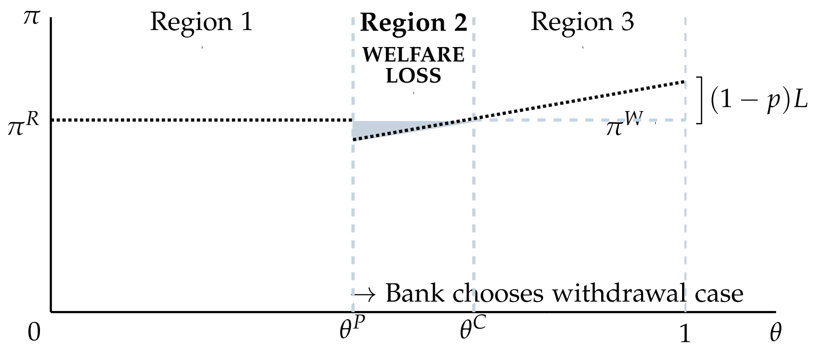
$$\theta > \theta^C = 1 - \frac{L}{pX} \tag{2.49}$$

For precision levels above θ^C, the signal's presence is actually beneficial. This expression is very similar to the bank's threshold $\theta^P = 1 - \frac{L}{p[X-1+T]}$ (2.36). Importantly, however, the latter always lies below θ^C

$$\theta^C > \theta^P \tag{2.50}$$

unless the bank refinances itself fully on the wholesale markets, i.e. unless $T = 1$, in which case $\theta^C = \theta^P$ as the bank fully internalizes all negative consequences of its decisions.

The gap between θ^P and θ^C, i.e. $\theta \in [\theta^P, \theta^C]$, and the positive slope of the total welfare function, $\frac{\partial \pi^W}{\partial \theta} > 0$, are illustrated in figure 2.9. The distance between the two critical precision levels is particularly wide when banks are mostly funded by deposits, i.e. when wholesale funding T only constitutes a small share of the bank's liability side. The latter clarifies that the bank's inefficient choice is due to the fact that it ignores the bail-out costs which are borne by the public and that the bank's incentives to willingly accept its funding instability are highest when deposit funding is substantial.



The figure shows welfare in the market equilibrium (black dotted line) as a function the market signal's precision θ. For $\theta \in [\theta^P, \theta^C]$ the unregulated bank chooses to violate the $\bar{s}$ constraint and thereby willingly accepts withdrawals upon noisy signals at date 1, although not doing so (roll-over) would be socially optimal.

FIGURE 2.9: Welfare loss due to bank's choice

THREE REGIONS: Within the region $\theta \in [\theta^P, \theta^C]$ the bank therefore chooses $s = 1, h = 0$ although this causes its liquidation based on a negative signal and although this reduces overall welfare (blue triangle). Plugging $\theta^P = 1 - \frac{L}{p[X-1+T]}$ and $\theta^C = 1 - \frac{L}{pX}$ respectively into (2.48) shows that this loss equals $-(1-p)\frac{1-T}{X-1-T}$ at θ^P and that it is zero at θ^C. Below θ^P and above θ^C the market equilibrium and the first-best outcome coincide, which is why there is no need for intervention; for precision levels $\theta \in [\theta^P, \theta^C]$, however, the former lies below the latter; overall welfare is destroyed due to the bank's preference of $s = 1, h = 0$ over $s \in [0, \bar{s}], h = 0$. Three regions can be differentiated: **region 1,** in which the bank chooses the roll-over case and sets $s \in [0, \bar{s}], h = 0$, which is socially optimal; **region 2,** in which the bank chooses $s = 1, h = 0$ although this shrinks overall market welfare; and **region 3,** in which the bank chooses $s = 1, h = 0$ as well, but in which case the presence of the signal actually enhances overall welfare; for a fully precise update this welfare benefit amounts to $(1-p)L$, i.e. the gain from liquidating a bad bank, which would go bankrupt at date 2, already at date 1 when a value $L > 0$ can still be recovered. In conjunction with lemmas (1), (2), (3), and (4) these insights establish the following proposition.

Proposition 3. *Three regions must be differentiated with regard to the signal's precision and its effect on welfare in the market equilibrium: For updates which arrive with a precision level $\theta < \theta^P$, the bank chooses the roll-over case and sets $s \in [0, \bar{s}], h = 0$; updates of such precision have no effect on total welfare. For $\theta \in [\theta^P, \theta^C]$ the bank prefers the withdrawal case and chooses $s = 1, h = 0$; but overall expected welfare, i.e. π^W, then lies below welfare in the roll-over case, i.e. π^R; signals of that sort are thus problematic; the region exists if bank is at least partially funded by deposits. For $\theta > \theta^C$ the bank goes for $s = 1, h = 0$ as well, but in this case its decision to do so also enhances total welfare; the presence of signals of such high precision is thus clearly beneficial.*

2.5.2 First-best

REGULATOR INTERVENES: Based on proposition 3, the regulator, who maximizes total welfare, intervenes when the signal arrives with a precision level $\theta \in [\theta^P, \theta^C]$. It can do so either by legally constraining the maximum level of creditor rights the bank can offer to its wholesale financiers at date 0 or by prescribing a minimum HQLA requirement for the bank. Looking at the relevant derivatives of the welfare function π^R reveals that total welfare within the roll-over regime does not depend on the level of wholesale creditor rights but shrinks in HQLA requirements:

$$\frac{\partial \pi^R}{\partial s} = 0 \tag{2.51}$$

$$\frac{\partial \pi^R}{\partial h} = -pX + 1 < 0 \tag{2.52}$$

The regulator therefore constrains the bank's choice to a maximum level of creditor rights, i.e. $s \leq \bar{s}$, but prescribes no HQLA holdings. Again, the regulator's intervention is only necessary for $\theta \in [\theta^P, \theta^C]$, i.e. **region 2** in figure 2.10, as highlighted by the green line in the blue shaded area, within which the bank would choose $s = 1, h = 0$ instead.

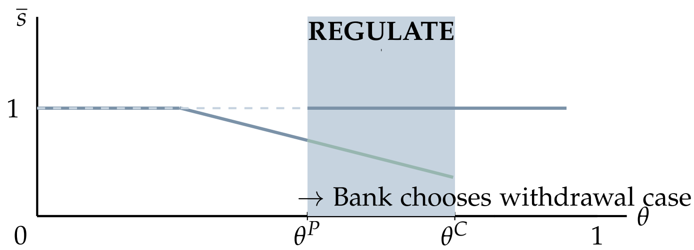


FIGURE 2.10: Creditor rights regulation

The regulator's intervention exerts two effects: First, it increases total economic welfare by eliminating inefficient withdrawals, i.e. the blue shaded triangle in figure 2.9. Second, it reduces implicit bank subsidies by shifting expected welfare from the bank to the deposit insurer; the latter no longer has to bail-out depositors upon bank defaults due to withdrawals upon a negative market signal, while the former is constrained to $s \in [0, \bar{s}], h = 0$, although it would instead be profit-maximizing to implement $s = 1, h = 0$.

Proposition 4. *For updates of precision $\theta \in [\theta^P, \theta^C]$, the regulator establishes the first-best optimum by constraining the bank's choice to $s \in [0, \bar{s}], h = 0$. Bank liquidations are then not based on the noisy market signal; bail-outs are needed less often. The bank's expected profit is smaller than in the unregulated market equilibrium due to higher refinancing costs. The overall welfare benefit from the regulator's interventions comes from the difference between avoided bail-out costs, which are neither accounted for by the bank nor by the wholesale financiers, and the reduced bank profit.*

2.6 International dimension

Consider now a situation, in which (i) the short-term wholesale financier invests funds from local ($(1-\omega)T$) as well as foreign sources (ωT) into the bank, and in which (ii) the regulator intervenes to constrain the bank because the signal arrives with a precision level $\theta \in [\theta^P, \theta^C]$. The question then is how these cross-border flows alter the regulator's choice between limiting creditor rights s and prescribing HQLA requirements h. The consideration of this international dimension is crucial because, as highlighted in the introduction, European banks had been aggressively absorbing short-term liabilities from foreign financiers, ωT, until the onset of the crisis, which is why most regulatory decisions in the last few years have involved an important international dimension.[19]

2.6.1 Benchmark

Common deposit insurance: The fact that the wholesale financier invests funds from international and local sources implies that total welfare π^R is now the sum of the following functions:

$$\pi_B^R = p(X-1)(1-h) - pT(R^R-1) \quad (2.53)$$
$$\pi_T^R = \omega[pTR^R + (1-p)sh - T] + (1-\omega)[pTR^R + (1-p)sh - T] \quad (2.54)$$
$$\pi_D^R = p(1-T) + (1-p)(1-T) - (1-T) \quad (2.55)$$
$$\pi_S^R = -(1-p)(1-T) + (1-p)(1-s)h \quad (2.56)$$

Note the distinction between local and foreign wholesale funds in (2.54): Since adding up these parts yields the following aggregate welfare function

$$\pi^R = p(1-h)X + h - 1 \quad (2.57)$$

it becomes apparent, however, that the regulatory decision problem is identical to the one outlined in section 2.5.2, i.e. the one of the regulator in a scenario without cross-border funding. The regulator chooses $s \leq \bar{s} \in [0, \bar{s}], h = 0$ rather than $s = \bar{s}, h = 1$, i.e. the creditor rights constraint rather than the HQLA instrument because the total welfare function he optimizes does not depend on s but shrinks in h.

Fragmented deposit insurance: If deposit insurance is provided separately in each country, however, outflows to foreign agents must be considered. The regulator thus considers each country's welfare independently:

$$\pi_{T\omega}^R = \omega[pTR^R + (1-p)sh - T] \qquad \begin{aligned} \pi_B^R &= p(X-1)(1-h) - pT(R^R-1) \\ \pi_{T1-\omega}^R &= (1-\omega)[pTR^R + (1-p)sh - T] \\ \pi_D^R &= p(1-T) + (1-p)(1-T) - (1-T) \\ \pi_S^R &= -(1-p)(1-T) + (1-p)(1-s)h \end{aligned}$$

Adding up the individual welfare functions of the agents abroad ($\pi_{T\omega}^R$) and in the host country and and using $R^R(s,h) = \frac{T-(1-p)sh}{pT}$ yields 0 and $p(1-h)X + h - 1$, respectively. The outflows to foreign wholesale financiers, $\pi_{T\omega}^R$, are zero in expectation and therefore constitute no problem for the deposit insurer in the bank's host country. The regulator again chooses $s \leq \bar{s} \in [0, \bar{s}], h = 0$ because aggregate welfare in a fragmented scenario, π_F^R, is independent from the level of creditor rights but depends

[19] Brunnermeier et al. (2009), for instance, mention the conflict about whether the British FSA should be allowed to require foreign-owned subsidiaries to hold specified ratios of British public sector debt.

negatively on HQLAs:

$$\pi_F^R \quad = \quad p(1-h)X + h - 1 \tag{2.58}$$

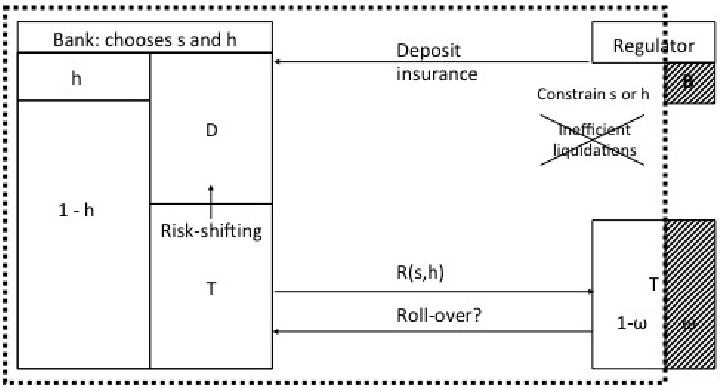
Proposition 5. *Cross-border capital flows through the banking system per se cause no regulatory switch. The welfare-maximizing regulator in a scenario in which deposit insurance is provided separately in each country opts for the exact same form of intervention as the regulator in a scenario with a common deposit insurance scheme (or the one in the model without international flows), i.e.* $s \in [0, \bar{s}], h = 0$. *Aggregate expected welfare equals* $pX - 1$ *in both scenarios.*

2.6.2 Extension: Costs of fragmented deposit insurance schemes

The pre-crisis build-up of substantial cross-country exposures on the funding side of European banks, however, came at considerable costs once foreign counter-parties started to withdraw. Among other factors, these costs were due to the euro zone's fragmented structure of deposit insurance schemes and fiscal budgets. They became apparent when national deposit insurers (i.e. the governments) were repeatedly forced to bail out failing banks: Public debt burdens of numerous countries escalated. Nations with comparatively sizeable banking sectors were particularly susceptible. This resulted in a loss of confidence in the sovereigns' creditworthiness and made them subject to financial speculation. Rating agencies and investors downgraded their credit rating or demanded higher interest rates on new sovereign bond issues, respectively. The resulting sovereign debt crisis caused significant uncertainties, painful structural reforms, tax increases, and problematic costs and distortions in the economic system as a whole. Assumption 3 accounts for these costs and summarizes the main condition of this section.

Assumption 3. *Fragmentation costs* $B > 0$ *materialize for the deposit insurer (i.e. the bank's host country) if the bank defaults and deposit insurance has to be covered separately by each nation. These costs rise proportionately in the deposit insurer's obligations towards depositors that cannot be covered by the bank's liquidation value that remains within the host country.*

I argue that B exists because an (often small) national deposit insurer may be overwhelmed with the magnitude of claims from depositors of large multinational banks, while a (large) common European insurer may find it easier to satisfy such obligations. The circumstance that, in expectation, the costs B in the bad state are not compensated by positive effects in the good state is exemplified by the developments of European sovereign bond spreads over time: although debt servicing costs fell for peripheral countries after the introduction of the Euro, when banks in the periphery were booming and financing local investments and growth, they rose significantly faster upon the onset of the crisis when banks ran into trouble. The schematic consequences of the existence of B and ω are illustrated in figure 2.11.



This figure summarizes major mechanisms and agents of the model. The shaded boxes depict foreign wholesale funds and costs due to fragmented deposit insurance schemes. The dashed frame indicates the national border.

FIGURE 2.11: Schematic representation

While costs B do not exist in a scenario with a **common deposit insurer**, in which case the regulator again chooses $s \in [0, \bar{s}], h = 0$, they are present in a scenario with **fragmented deposit insurance** schemes. In this case, they alter the pay-off function of the deposit insurer (i.e. the government) in the bank's host country: As it can be seen in (2.59), with a probability $1 - p$, the latter has to cover the deposit insurance scheme, i.e. $1 - T$. For that purpose, the deposit insurer can use the depositors' share of the liquidation value, i.e. $(1 - s)h$. Additionally, it may tax local wholesale financiers – for simplicity assume that he can obtain their full pay-off, i.e. $(1 - \omega)sh$ (ωsh of the liquidation value goes to foreign wholesale financiers, who cannot be taxed in the bank's host country). The residual, i.e. $1 - T - h(1 - \omega s)$, corresponds to the national deposit insurer's commitment to its insurance scheme which cannot not be covered by its proceeds from the bank's liquidation. It constitutes a loss which is multiplied by the cost parameter B in accordance with assumption 3. The welfare functions consequently present themselves as follows:

$$\pi^R_{T\omega} = \omega[pTR^R + (1-p)sh - T]$$

$$\begin{aligned}
\pi^R_B &= p(X-1)(1-h) - pT(R^R - 1) \\
\pi^R_{T^{1-\omega}} &= (1-\omega)[pTR^R + (1-p)sh - T] \\
\pi^R_D &= p(1-T) + (1-p)(1-T) - (1-T) \\
\pi^R_S &= -(1-p)(1-T) + (1-p)(1-s)h \\
&\quad -(1-p)B[1 - T - h(1-\omega s)]
\end{aligned}$$

Aggregate welfare therefore collapses to

$$\pi^R_F \quad = \quad p(1-h)X + h - 1 - \max\Big\{(1-p)B[1 - T - h(1-\omega s)], 0\Big\} \qquad (2.59)$$

where the term $\max\{(1-p)B[1 - T - h(1-\omega s)], 0\}$ indicates the costs of fragmented deposit insurance schemes which cannot be smaller than zero. In order to stabilize the deposit insurer (i.e. the government) of the bank's host country, it is in the regulator's interest to keep as much money within this nation as possible.[20]

The regulator's choice of the level of wholesale creditor rights is straightforward: In the presence of foreign wholesale financiers and when the bank holds HQLAs, i.e. for $\omega > 0, h > 0$, he sets maximum creditor rights as low as possible, i.e. $s = 0$, in order to prevent outflows. For $\omega = 0$ or $h = 0$, however, there are no outflows to foreign financiers, which is why he is just indifferent between all $s \in [0, \bar{s}]$. The regulator's choice of minimum HQLA requirements, however, depends on the size of the costs of fragmented deposit insurance, B: He chooses $h = 0$ if these are relatively low, i.e. if $B < \tilde{B} = \frac{pX-1}{(1-\omega s)(1-p)}$, and $h = 1 - T$[21] otherwise. The threshold $\tilde{B}$ obviously depends on the level of s, but, because the threshold is highest when s equals one, it always holds that

$$h = \begin{cases} 0, & \text{if } B < \tilde{B} = \frac{pX-1}{(1-\omega)(1-p)} \\ 1-T, & \text{if } B > \tilde{B} = \frac{pX-1}{(1-\omega)(1-p)} \end{cases} \tag{2.60}$$

Depending on the costs the bank default imposes on the host country's deposit insurer the solution is therefore either $s \in [0, \bar{s}], h = 0$ or $s = 0, h = 1 - T$. Both guarantee that funds are rolled-over at date one, i.e. that $s \leq \bar{s}$ as in (2.24).

Proposition 6. *Cross-border capital flows through the banking system cause a regulatory switch in the presence of fragmentation costs B. The regulator in a scenario in which deposit insurance is provided separately by an insurer in each country always constrains maximum wholesale creditor rights to the minimum, and, if B is sufficiently high, additionally imposes minimum HQLA requirements* $h = 1 - T$*. To be precise, the regulator chooses* $s \in [0, \bar{s}], h = 0$ *if costs are low, i.e. if* $B < \tilde{B}$*, in which case total welfare equals* $\pi_F^R(s \in [0, \bar{s}], h = 0) = pX - 1 - (1-p)B(1-T)$*; he opts for* $s = 0, h = 1 - T$*, however, if the costs are high, i.e. if* $B > \tilde{B}$*, in which case total welfare equals* $\pi_F^R(s = 0, h = 1 - T) = T(pX - 1)$*. At* $B = \tilde{B}$ *he is indifferent between the two options.*

The regulator's choices for the benchmark case and the extension with and without fragmentation are summarized in figure 2.12.

2.6.2.1 Welfare implications on the aggregate level

The regulatory switch from $s \in [0, \bar{s}], h = 0$ to $s = 0, h = 1 - T$ in the presence of fragmentation carries important welfare implications: Subtracting $\pi_F^R(s \in [0, \bar{s}], h = 0)$

[20] Austria's fight with Germany over the default of the Austrian Hypo AlpeAdria bank, in which German (and some Austrian) wholesale creditors were not fully repaid in order to protect local depositors and tax payers, serves as a recent example, in which, however, Austrian authorities implemented a 'bail-in' ex post. The dispute came at the cost of significant legal costs and uncertainty; the bail-in was ultimately declared void by Austria's constitutional court.

[21] At $h = 1 - T$ the deposit insurance scheme is fully covered by the liquidation value anyway. Requiring more therefore does not bring additional benefits.

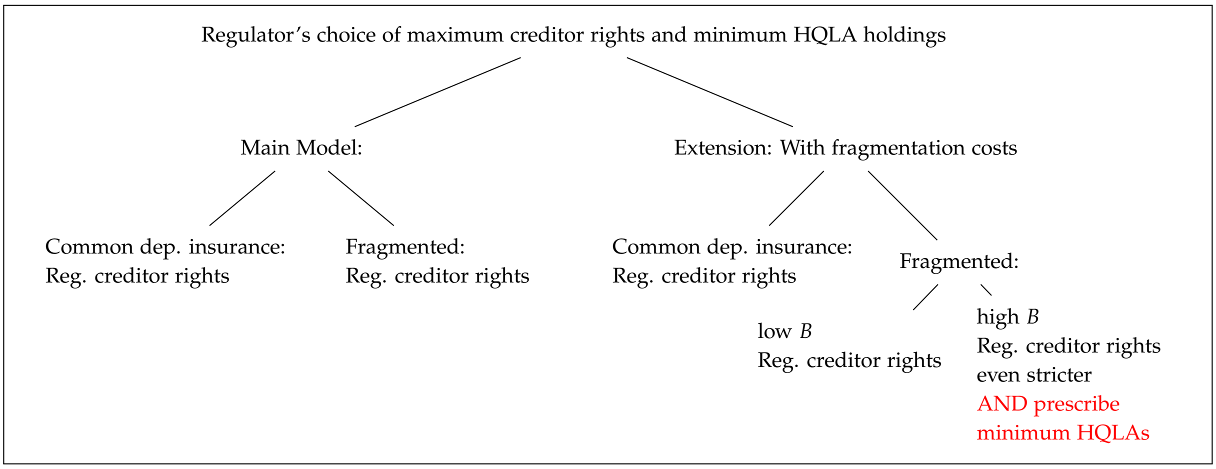


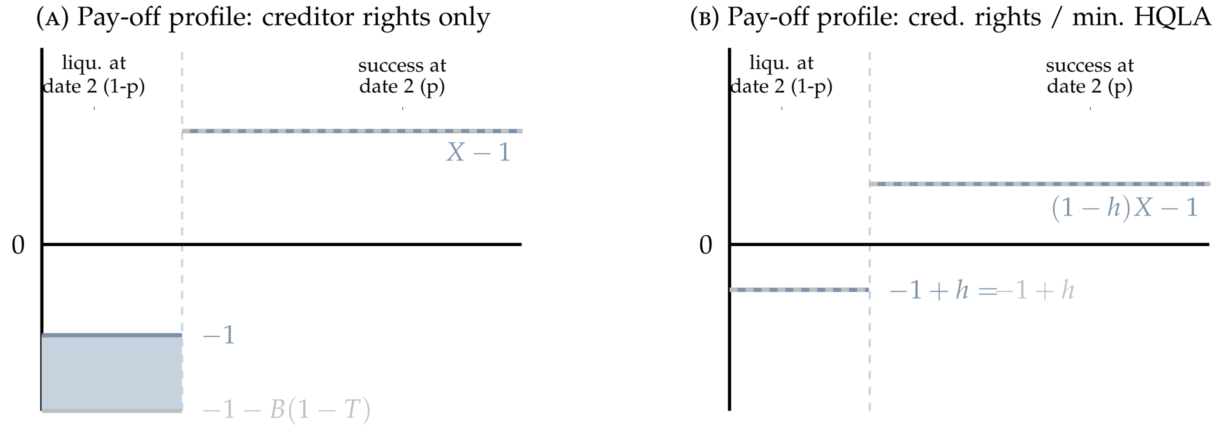
FIGURE 2.12: International policy decisions with and without fiscal fragmentation

from $\pi_F^R(s=0, h=1-T)$ yields

$$\pi_F^R(s=0,h=1-T) - \pi_F^R(s \in [0,\bar{s}], h=0) = \overbrace{(1-p)(1-T)B}^{\text{lower fragmentation costs}} - \underbrace{(pX-1)(1-T)}_{\text{lower investment return}} \tag{2.61}$$

The positive effect $(1-p)(1-T)B$ is due to the fact that minimum HQLA requirements avoid costs of fiscal fragmentation since the local deposit insurer can fully cover its obligations towards depositors by using the liquidation value of the bank, i.e. $h = 1-T$. The negative term $(pX-1)(1-T)$, on the other hand, arises because minimum HQLA requirements constrain the bank's investment options and thus reduce aggregate welfare. The positive effect dominates for all levels of ω if $B > \tilde{B}$.

The intuition for the regulator's decision to only prescribe minimum HQLAs when the costs B are sufficiently sizeable becomes apparent from graphs (A) and (B) in figure 2.13, where the blue and gray lines depict welfare in a scenario with and without common deposit insurance, respectively. In a scenario with common deposit insurance, the expected value across the two regimes (success, liquidation at date 2) is always higher under the $s \in [0,\bar{s}], h = 0$ scenario as shown in sections 2.5.2 and 2.6.1. Thus, if needed, the regulator always opts for the constraint on the maximum level of wholesale creditor rights but never requires banks to hold minimum HQLA buffers. In a scenario in which deposit insurance is fragmented, however, this choice would cause significant costs, i.e. $B(1-T)$, the blue shaded area in graph (A). The regulator can avoid these costs by implementing $s = 0, h = 1-T$ instead of $s \in [0,\bar{s}], h = 0$ as there are then no outflows to foreign agents and because the deposit insurance is fully covered by the date-2-bank liquidation value $1-T$. In a scenario with fragmented deposit insurance, the regulator therefore becomes more inclined to choose the $s = 0, h = 1-T$–option and does so if $B > \tilde{B}$.



The graphs show total welfare depending on whether the bank succeeds or fails with (gray lines) and without (blue lines) fragmentation costs. (A) shows welfare for the creditor rights regime (i.e. when only max. creditor rights are imposed) while (B) shows welfare for a scenario in which the regulator imposes min. HQLAs as well as max. creditor rights.

FIGURE 2.13: Regulatory switch in the presence of fragmentation costs

Proposition 7. *The regulator's decision to not only constrain creditor rights but to also introduce min. HQLA requirements in a scenario in which deposit insurance schemes are fragmented and cause high costs, i.e. to choose $s = 0, h = 1 - T$ rather than $s \in [0, \bar{s}], h = 0$ when $B > \tilde{B}$, maximizes total welfare; albeit at a lower level compared to a scenario with common deposit insurance.*

2.6.2.2 Welfare implications for the individual agents

It is particularly interesting to investigate how the regulatory switch due to fragmentation affects the different agents: **Depositors** and **short-term wholesale financiers** are obviously not concerned; it has already been established that both creditors just receive back their initial investment in expectation. The **deposit insurer**, however, clearly gains when HQLAs are regulated as well as his welfare function changes from $\pi_S^R(s \in [0, \bar{s}], h = 0) = -(1-p)(1-T)[1+B]$ to $\pi_S^R(s = 0, h = 1 - T) = 0$. His exact benefit is

$$\Delta\pi_S^R = \pi_S^R(s = 0, h = 1 - T) - \pi_S^R(s \in [0, \bar{s}], h = 0) = \underbrace{(1-p)(1-T)[1+B]}_{>0} \tag{2.62}$$

The **bank**, on the other hand, generates less investment profits when minimum HQLAs are imposed. Using the bank's expected profit functions under the two regimes, i.e. $\pi_B^R(s \in [0, \bar{s}], h = 0) = p(X-1) - pT[R^R - 1]$ and $\pi_B^R(s = 0, h = 1 - T) = p(X-1)T - pT[R^R - 1]$ and plugging in $R^R = \frac{T-(1-p)sh}{pT}$, which equals $R^R = \frac{1}{p}$ in both cases, yields

$$\Delta\pi_B^R = \pi_B^R(s = 0, h = 1 - T) - \pi_B^R(s \in [0, \bar{s}], h = 0) = -p(X-1)[1-T] \tag{2.63}$$

The bank thus clearly loses from the regulatory switch. Adding up (2.62) and (2.63) yields the total welfare change:

$$\Delta\pi_S^R + \Delta\pi_B^R \;=\; \underbrace{(1-p)(1-T)B}_{\text{lower fragmentation costs}} - \underbrace{(pX-1)(1-T)}_{\text{lower investment return}} \tag{2.64}$$

The latter is equal to expression (2.61) and confirms that the regulator's decision to additionally introduce minimum HQLA requirements is strictly welfare optimal if the guaranteed, stable share of the liquidation value, $h = 1 - T$, avoids sufficiently large fragmentation costs, i.e. if $B > \tilde{B}$.

Proposition 8. *The regulator's decision to choose $s = 0, h = 1 - T$ rather than $s \in [0, \bar{s}], h = 0$ when $B > \tilde{B}$, reduces the fragmentation costs for the deposit insurer in the bank's host country but also diminishes the profits of internationally funded banks. The establishment of a common European deposit insurance scheme, within which B does not exist, should thus benefit the latter.*

Regulatory decisions of that sort are likely to arise in the euro area, within which banks engage in substantial cross-border lending and within which financial developments have outpaced the speed of fiscal and supervisory integration by far. Although Europe's largest 120 banks are now supervised by the ECB, such problems are likely to persist as budgets and deposit insurance schemes are still fragmented and regulatory decisions are made by representatives of national governments, who defend their vested interests.

2.7 Discussion

The set-up of this model is built on several pivotal premises that deserve some clarifying comments. *First,* the fact that short-term creditors are sensitive to information and impose an interest rate on the bank, whereas depositors do not, drives a wedge between the two funding classes. This incentivizes the bank to prefer short-term wholesale financiers over retail depositors when it determines the conditions of the debt contracts at date 0. The model is therefore essentially about risk-shifting between debt categories. *Second,* the possibility to regulate creditor rights in a continuous way offers an innovative contractual alternative to a strict seniority hierarchy according to which claims are fully settled in default until all funds are eventually used up. The variable is ideally interpreted to depict automatic stays, deferred pay-outs or a tax on early withdrawals from wholesale financiers (redemption fees). It therefore also captures the time dimension, which is particularly useful for topics of liquidity. Due to this time aspect and given that creditor rights, s, specify the share of the liquidation value allocated to non-depositors, a comparison to bail-in ratios, which indicate the loss-absorbing fraction of the creditor's claims during resolution, should be used with caution. These features offer room for a rich variety of interpretations and adequately reflect realities on financial markets. *Third,* the concrete implementation of the two instruments – creditor rights and HQLAs – discussed requires considerable caution: a limit on creditor rights, for instance, makes wholesale investments into the bank less liquid as 'covenant lite' positions of that sort would require larger price movements in order to find buyers in a stressed environment. Such a feature may exacerbate price volatility and put pressure on collateral management in the shadow banking sector where many of these funds are coming from. A minimum HQLA requirement on the other hand may reinforce the infamous nexus between bank and sovereign risk if government bond holdings within the HQLA segment are not diversified enough. *Fourth,* since only two assets are available, asset substitution into riskier investments, from which the bank may benefit in the upside, is no option. In reality, however, the recent 'hunt for yield' has demonstrated that financial agents may do exactly that. *Fifth,* neither of the two debt categories is capable of truly disciplining the bank, i.e. to increase the success probability of the project, or to assume the role of the regulator, i.e. to introduce regulatory instruments. 'Monitoring' in the traditional sense is thus not taking place. This feature receives support from Rochet and Tirole (1996), who show that existing monitoring incentives may be undermined *ex ante* when the government is anticipated to bail-out failing banks *ex post*, as well as Dewatripont and Tirole (1994), who argue that depositors may be too small and dispersed to execute this task. Such a set-up is furthermore consistent with the arguments by Admati et al. (2013), Admati and Hellwig (2013b) and Pfleiderer (2014), who writes that *'... the notion that short-term debt plays a critical role in disciplining bank managers in the actual world seems to be based on chameleons: theoretical results have been taken off the bookshelf and applied to the real world without passing them through a reasonable filter.'* The authors also claim that the disciplining view does not match the facts as banks' short-term maturity liability structure did not stop them from accumulating large quantities of opaque and risky assets in the-run up to the crisis. They criticize that many models assume information insensitivity and the disciplining role at the same time, which is a contradiction in itself.

2.8 Conclusion

This paper is the first to study the effects of bank short-term wholesale funding from local and foreign sources, the role of HQLA buffers and wholesale creditor rights, and the consequences of common and fragmented deposit insurance schemes in combination. Although similar environments can be observed around the world, these building blocks are nowhere more visible and problematic than they are in Europe, where the speed of financial integration has outpaced financial supervisory structures and fiscal unification by far, and where regional booms cause considerable imbalances in the banking sector.

The analysis tries to understand the implications of this setting and suggests best-possible policy responses. It regards the bank's funding side as a conglomerate of two heterogeneous debt categories: short-term wholesale funds and insured retail deposits. Other studies often focus on the well-established conflicts between equity and debt holders instead and consider the latter as a homogeneous group. I first establish how the bank allocates its assets between safe, low-yield HQLAs and risky, more profitable projects as well as how it sets wholesale creditor rights. In order to lower its funding cost – and to maximize its profits – the bank has every incentive to grant excessive creditor rights to its wholesale financiers and thereby shifts risk to depositors (i.e. the public). Also, it invests as much as possible in relatively profitable but risky investment projects thus under-hoarding HQLAs. Both choices increase financial instability and cause welfare inefficiencies as they give way to unnecessary roll-over risk; overly reactive wholesale financiers run on the bank even upon rather noisy market signals. But the bank may willingly accept its own fragility if it benefits from higher profits in expectation. It does so because bail-out costs are ultimately borne by the deposit insurer. The bank's choice may, therefore, destroy total welfare in the economy.

I subsequently discuss two policy instruments: minimum HQLA requirements for banks and a maximum limit on wholesale creditor rights. In consideration of the specific costs and benefits that come with the two options, the regulator always chooses the latter. This intervention increases the bank's refinancing costs and thereby reduces implicit subsidies and, for a certain precision level of market signals, it improves their funding stability and lifts total welfare to its first-best optimum.

The highest welfare level is reached in a scenario with a (financially potent) common deposit insurer. The current lack of such a centralized insurance scheme may lead to situations in which (often small) national deposit insurers are overwhelmed with the magnitude of claims from depositors of large multinational banks, which may cause significant turmoil. If these difficulties trigger substantial costs, the regulator rationally decides to not only constrain creditor rights but to also impose minimum HQLA buffers. This avoids the costs of unbearable obligations towards depositors but entails a reduction of profits from riskier, more profitable investment projects. I thus find that the establishment of a true European deposit insurance scheme should not only foster economic welfare of the region as a whole but that it should also be to the benefit of banks, the latter of which constitutes an interesting novelty of this paper. Overall, the predictions of the model are broadly consistent with recent developments and of particular importance for evaluating current attempts to reshape European bank supervision.

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Appendix

2.A List of notations

	Variables	
s	Creditor rights: Share of the bank's liquidation value at date 1 or date 2 attributed to short-term wholesale financiers: (a) size dimension: wholesale creditor rights decrease if they suffer haircuts for withdrawals, if they are not paid out in full, if only a fraction is paid out on demand; (b) time dimension: wholesale creditor decrease if supervisor can shut down bad banks faster than they can withdraw, if payouts can be deferred or delayed, if there are automatic stays, if maturities for wholesale financiers are increased;	$s \in [0,1]$
h	High quality liquid asset (HQLA) holdings of the bank, low-yield, minimum requirements may be imposed by the regulator	$h \in [0,1]$
$\bar{s}$	Maximum creditor rights a bank can allocate to short-term wholesale financiers; set by the regulator	$\bar{s} \in [0,1]$
R^R	Interest rate on short-term wholesale funds in the roll-over case	$R > 1$
R^W	Interest rate on short-term wholesale funds in the withdrawal case	$\tilde{R} > 1$
θ^P	Precision of the date 1 market signal, above which the bank chooses s and h such that short-term wholesale financiers withdraw their funding to the bank upon negative information	$\theta^P \in [0,1]$
θ^C	Precision of the date 1 market signal, above which it would be socially optimal to choose s and h such that short-term wholesale financiers withdraw their funding to the bank upon negative information	$\theta^C \in [0,1]$
	Parameters	
X	Profitability of risky long-term investment projects the bank can invest in	$X > 1$
p	Success probability of risky long-term investment projects	$p \leq 1$
L	Liquidation value of the risky long-term investment projects when prematurely liquidated at date 1	$L < 1$
R_h	Return on HQLAs	1
T	Share of short-term wholesale funds in total bank funding	$T \in [0,1]$
D	Share of deposits in total bank funding	$1 - T$
R_D	Interest rate on deposits	1
θ	Precision of the market signal at date 1	$\theta \in [0,1]$
ω	Share of short-term wholesale funding coming from foreign financiers	$\omega \in [0,1]$
B	Fragmentation costs which materialize for the deposit insurer (i.e. the bank's host country) if the bank defaults and deposit insurance has to be covered separately by each nation. These costs rise proportionately in the deposit insurer's obligations towards depositors that cannot be covered by the bank's liquidation value that remains within the host country.	$B \geq 0$

Table 2.2: List of notations

2.B Proofs and derivations

Proof for section 2.5.1: The bank's decision problem within the roll-over regime

The bank maximizes its profit by choosing creditor rights s and HQLA holdings h. In order to stay within the roll-over regime it has to respect the constraint $\bar{s}$, and pays wholesale financiers an interest rate just equal to their participation constraint (2.23). Using $R^R(s,h) = \frac{T-(1-p)sh}{pT}$ from (2.23) and solving for s yields the following problem

$$\max_{s,h,\lambda} p\left[(X-1)(1-h) - T\left(\frac{T-(1-p)sh}{pT} - 1\right)\right] - \lambda\left(s - \bar{s}\right) \tag{2.65}$$

and first-order conditions:

$$\frac{\partial \mathcal{L}}{\partial s} = (1-p)h - \lambda = 0 \tag{2.66}$$

$$\frac{\partial \mathcal{L}}{\partial h} = -p(X-1) + (1-p)s + \lambda\frac{\partial \bar{s}}{\partial h} = 0 \tag{2.67}$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = s - \bar{s} \leq 0 \tag{2.68}$$

$$\lambda\frac{\partial \mathcal{L}}{\partial \lambda} = 0 \tag{2.69}$$

FOC (2.66) implies that λ is non-negative; this is because the term $(1-p)h$ is either positive (for $h > 0$) or zero (for $h = 0$). By complementary slackness (2.69), the constraint binds such that the bank grants as high creditor rights as possible to remain within the roll-over regime, i.e. $s = \bar{s}$. In order to determine the choice between s and h one needs to determine the profit maximizing h. For that purpose, one has to look at FOC (2.67). The sign of $\frac{\partial \bar{s}}{\partial h}$, where $\bar{s} = \frac{(1-\theta)T}{(1-h)L+h(1-\theta)}$, is critical for its sign. The effect of HQLA holdings on the threshold $\bar{s}$ can be written as follows:

$$\frac{\partial \bar{s}}{\partial h} = \frac{(1-\theta)T[L-(1-\theta)]}{[(1-h)L+h(1-\theta)]^2} \tag{2.70}$$

Whenever $(1-\theta) > L$, (2.70) is negative and, given the non-negative λ, FOC (2.67) is negative as well – recall that the analysis in the main text focuses on a situation, in which the term $-p(X-1)+(1-p)s$ is negative (see assumption 2). The bank therefore never chooses to hold positive levels of HQLAs: This is because HQLA holdings make the bank more susceptible to withdrawals. It thus has to constrain creditor rights stronger when it holds HQLAs; the bank's expected profit then decreases in its HQLA holdings. Such a scenario is depicted in figure 2.4 (a). Whenever $(1-\theta) < L$, however, the derivative (2.70) is positive. The bank can then relax its limit on creditor rights. HQLA holdings exert a stabilizing impact on the bank which is more intuitive from an economic perspective and the basic reasoning of the Basel Committee's liquidity requirements. The bank can then relax the limit on creditor rights when it chooses to hold more HQLAs. It cannot go above $\bar{s} = T$, which it reaches at $h = 1$. Such a scenario is depicted in figure 2.4 (b).

Based on FOC (2.67), an interior solution thus seems to be possible only when $(1-\theta) < L$. However, one can show that the objective function is convex in h for $s = \bar{s} = \frac{(1-\theta)T}{(1-h)L+h(1-\theta)}$, in which case it looks as depicted in figure 2.4 (b). For that purpose, using $\lambda = (1-p)h$, one can first rewrite FOC (2.67) as follows:

$$\frac{\partial \mathcal{L}}{\partial h} = -p(X-1) + (1-p)\bar{s} + (1-p)h\frac{\partial \bar{s}}{\partial h} = 0 \tag{2.71}$$

Taking the second derivative of this FOC yields:

$$\frac{\partial^2 \mathcal{L}}{\partial h^2} = \underbrace{(1-p)\frac{\partial \bar{s}}{\partial h}}_{>0} + \underbrace{(1-p)\frac{\partial \bar{s}}{\partial h}}_{>0} + (1-p)h\frac{\partial^2 \bar{s}}{\partial h^2} \tag{2.72}$$

Since the first two terms are always positive when $\frac{\partial \bar{s}}{\partial h}$, as expressed in (2.70), is positive, i.e. when $(1-\theta) < L$, one can focus on determining the sign of $\frac{\partial^2 \bar{s}}{\partial h^2}$:

$$\frac{\partial^2 \bar{s}}{\partial h^2} = \frac{2(1-\theta)T[L-(1-\theta)]^2}{[(1-h)L+h(1-\theta)]^3} > 0 \tag{2.73}$$

(2.73) is clearly always positive such that any interior solution is profit-minimizing and a corner solution is chosen instead. Overall, while the bank never holds positive level of h for $(1-\theta) > L$ anyway, the bank's decision problem for $(1-\theta) < L$ thus boils down to choosing between $s \in [0, \bar{s}], h = 0$ and $s = \bar{s}, h = 1$, i.e. points A or B in figure 2.4 (b). The comparison between the bank's profits for these two options in (2.26) of the main text demonstrates that the bank always opts for the former. *Q.E.D.*

Online appendix

2.C Empirical evidence

It has been highlighted in the introduction that the likelihood to suffer from withdrawals from short-term wholesale financiers was lower for banks with solid liquidity coverage ratios during the onset of the crisis. This section describes the data set from which the results were derived in more detail and executes a number of robustness checks. Since this empirical contribution is not in the center of this paper, however, it is kept rather short and concise.

Data and measurement

The self-compiled data set combines data from BankScope as well as CapitalIQ and consists of 2,732 European financial institutions located in 24 countries. Given the vast variety and the huge differences in their characteristics and business models, the analysis is limited to commercial banks only. 405 institutions eventually remain in the sample, most of which are located in France (60), Germany (39), Italy (37), Denmark (30) and Switzerland (24). Banks vary considerably in the length of their 2008 balance sheets, which range from 3,500 billion USD for the Royal Bank of Scotland to 8.6 billion USD of the Banque Cantonale du Valais and even smaller institutions. As documented in table 2.4, twenty sample countries experienced a drop in the reliance on short-term funding measured as a percentage of total liabilities for their average bank between 2008 and 2009. These drops are based on the comparison of year-end balance sheet data. The change between these two points in time was chosen as the relevant threshold for this analysis because the outflows were strongest on aggregate at that date and because the European banking and sovereign debt crisis fully unfolded during that period. Overall, the ratio of short-term funding to total assets dropped by 1.21 percentage points. Columns (2) and (3) of the table 2.4 furthermore document that the majority of banks experienced outflows at that time and that considerable variation can be observed across countries. The data also reveals that the ratio of 'cash and cash equivalents to short-term debt' shows substantial heterogeneity across banks as some institutions seem to manage their maturity structure in a more prudent way then others. The empirical elements in this paper exploit this bank-level variation.

The subsequent regressions use the change of short-term funding as a percentage of total liabilities between 2008 and 2009 as the dependent variable. A bank with a high LCR ratio should be less susceptible to such drops because financiers assume that it will have enough money to cover short-term need for cash without having to liquidate long-term assets, which is why I would expect a positive coefficient for the LCR. A simple regression for 405 commercial banks in Europe, which uses a dummy variable (equals one for increases and zero for reductions) as the independent variable, confirms this reasoning: Institutions with relatively solid ratios of liquid asset holdings to short-term funds were in fact less likely to experience reductions of short-term funding. Concretely, a 100 percentage point higher ratio reduced the likelihood of short-term outflows by 1.5 percent.

TABLE 2.3: Funding stability – correlation coefficient

	Outflows of short-term funds
Liquid asset/S-T Funds	0.015**
	(2.52)
Obs	405

Linear probability model: dependent variable equals one if a bank's ratio of short-term funds to total liabilities increased or stayed constant after the onset of the crisis and zero otherwise. ** $p < 0.05$.

Table 2.4: In- and outflows of short-term funds

2008-2009 country	banks with inflows (1)	banks with outflows (2)	total	change of short-term funds % of total liab. (3)	change of short-term funds % of abs. level (4)
AUT	8	7	15	-3.31	1.01
BEL	4	5	9	-0.99	-0.01
CRO	2	6	8	-1.50	0.05
CYP	0	3	3	-1.42	-0.43
CZE	5	4	9	-0.25	0.10
DEN	12	18	30	-1.07	0.17
FIN	1	3	4	-1.80	0.17
FRA	19	41	60	-1.08	1.10
GER	20	19	39	2,84	0.65
GRE	3	5	8	0.18	0.44
ICE	0	2	2	-5.83	-0.63
IRE	3	1	4	2.99	0.12
ITA	6	31	37	-3.98	0.12
LIE	1	1	2	- 0.36	-0.06
LUX	3	5	8	-0.07	1.67
MLT	2	0	2	0.93	0.30
NED	2	7	9	-4.40	-0.04
NOR	5	16	21	-1.32	-0.00
POL	2	13	15	-2.38	-0.06
POR	0	3	3	-3.26	-0.47
ESP	7	16	23	-0.23	0.08
SWE	7	6	13	0.95	0.92
CHE	4	20	24	-1.71	-0.18

Further estimates

The positive impact of the liquidity coverage ratio on banks' funding stability is exposed to a wide set of further estimates in table 2.5. Regressions (1) to (8) use the continuous change of the ratio 'short-term funding to total liabilities' as a dependent variable. Column (1) of table 2.5 only uses the LCR ratio and equity as explanatory variables and confirms the initial hypothesis indicating that outflows were 0.2 percentage points lower on average for a 100 percentage point increase of the LCR ratio. Higher equity ratios had a stabilising effect as well. Concretely, a one percentage point rise of the equity ratio decreased the magnitude of outflows by 0.16 percentage points. Column (2) subsequently controls for the size of the bank measured as (i) the length of its balance sheet as well as (ii) the number of employees and includes a dummy which indicates whether a bank is listed on the stock exchange. The main results remain unchanged. Column (3) then adds a dummy for EMU membership of the country the bank is located in before columns (4) to (7) run the baseline regression for all size quartiles according to the size of a bank's assets. These outcomes suggest that the results are mostly driven by the largest and the third largest quartiles of sample banks. Running the regression only for EMU institutions (8) also makes no difference. In order to rule out a purely mechanical effect – the ratio of short-term funding is used to construct the dependent and the independent variable – regression (9) subsequently uses the binary dependent variable as in table 2.3, which takes on the value one if the bank's percentage of short-term funding remained robust or increased and zero otherwise. The coefficient confirms that the stabilizing effect of the LCR as reported in table 2.3 also holds when the equity ratio is controlled for as well. Specification (10) then applies another variation of the dependent variable defining it as the percentage change of the absolute level of short-term funds from 2008 to 2009. Column (11) eventually uses the nearest neighbour matching technique[22] to compare banks which are similar in terms of size, equity ratio, geographic location and the exact sector their are active in. All specifications control for sector-fixed effects, which express the precise business description of the bank, as well as country-fixed effects, which capture common shocks to all banks within the same nation and may best accommodate for potential cross-country differences in bankruptcy regimes and creditor rights. Robust standard errors are clustered on the country level. The key result concerning the LCR remains unaltered in all variations. Note that these results should be interpreted with caution since banks have been constrained only by the low reserve requirements from central banks *pre crisis*; liquidity regulation à la Basel III had not yet been introduced. The liquid asset holdings used in the regressions thus emerged endogenously.[23] Nevertheless, numbers suggest that banks that held a higher ratio of liquid asset to short-term debt before the onset of the crisis were significantly less likely to experience outflows of short-term wholesale funding, which is an important observation *per se*.

[22] The exact method is based on Abadie and Imbens (2002); Abadie et al. (2004) and Rosenbaum and Rubin (1983) and uses Abadie-Imbens heteroskedasticity-robust standard errors.

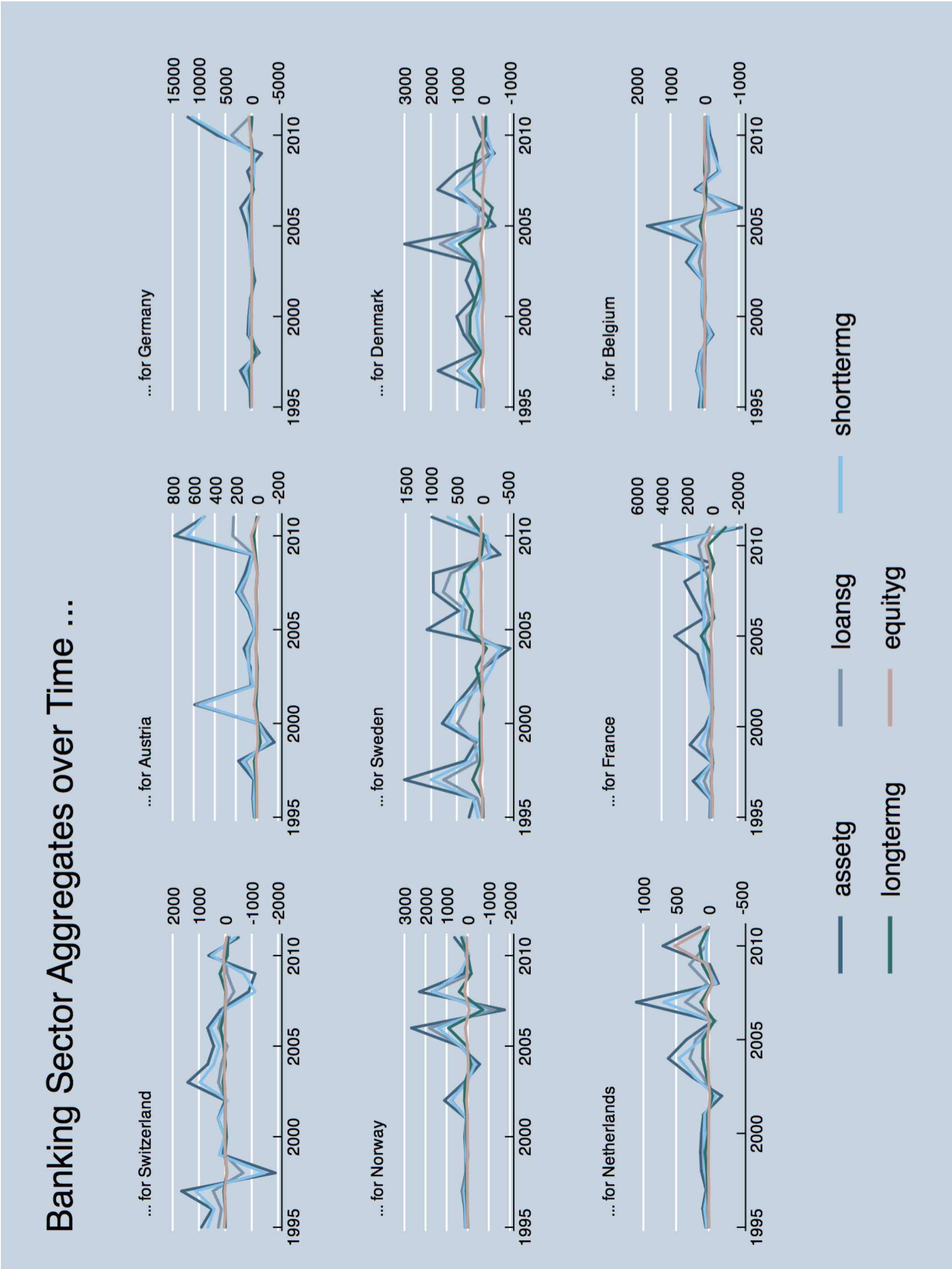
[23] Similarly, Holmström and Tirole (1998) show that intrinsic liquidity risk management motives may induce firms to voluntarily hold such reserves in the form of marketed assets that can be readily sold.

TABLE 2.5: Estimation results

	baseline	size, listed	EMU	size largest quartile	second-largest quartile	third-largest quartile	smallest quartile	EMU only	binary	alternative measure	matching
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
LCR	0.195***	0.196***	0.199***	0.235*	-0.039	0.276***	0.171	0.178**	0.010**	0.158**	
	(3.75)	(3.57)	(3.79)	(1.80)	(-0.38)	(3.02)	(1.46)	(2.76)	(2.22)	(2.48)	
Equity	0.163**	0.170*	0.168**	0.086	0.201	0.289	0.034	0.064	0.001	-0.009	
	(2.14)	(1.89)	(2.08)	(0.34)	(0.71)	(1.30)	(0.33)	(0.66)	(0.13)	(-0.31)	
Assets		0.299									
		(0.97)									
Listed		0.546									
		(1.06)									
Employees		-0.000***									
		(-3.24)									
EMU			2.157								
			(1.46)								
											(-2.18)
SATE											3.552***
											(6.99)
Constant	-2.074	-5.121	-3.632*	1.881***	-1.315	-4.964*	-8.054***	-0.339	0.821***	8.452	
	(-1.33)	(-1.19)	(-1.90)	(3.27)	(-0.40)	(-1.98)	(-4.86)	(-0.17)	(13.09)	(1.16)	
Obs	405	405	405	101	101	101	102	276	405	405	405
R2	0.3210	0.3484	0.3300	0.5345	0.5665	0.4852	0.4298	0.3484	0.2134	0.1761	

Two-tailed significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. T-statistics are reported in parenthesis. All estimations use robust standard errors clustered on the country-level and include country-specific and type-fixed effects. The latter are based on the bank's precise business segment description. Regressions (1) to (8) use the continuous change of the ratio 'short-term funding to total liabilities' as a dependent variable. Column (1) measures the effect of the LCR and equity ratios. Column (2) controls for the bank's size measured as the length of its balance sheet as well as the number of employees and includes a dummy which indicates whether a bank is listed on the stock exchange. Column (3) includes a dummy for EMU membership of the country hosting the bank. Columns (4) to (7) run the baseline regression for the largest quartile, second-largest quartile, third-largest quartile, and smallest quartile of banks according to the length of their balance sheet. (8) runs the regressions only for banks in the EMU. (9) uses a binary dependent variable (see table 2.3), which takes on value one if the bank's percentage of short-term funding remained robust or increased and zero otherwise. Specification (10) defines the dependent variable as the percentage change of the absolute level of short-term funds from 2008 to 2009. Column (11) eventually uses the nearest neighbour matching technique.

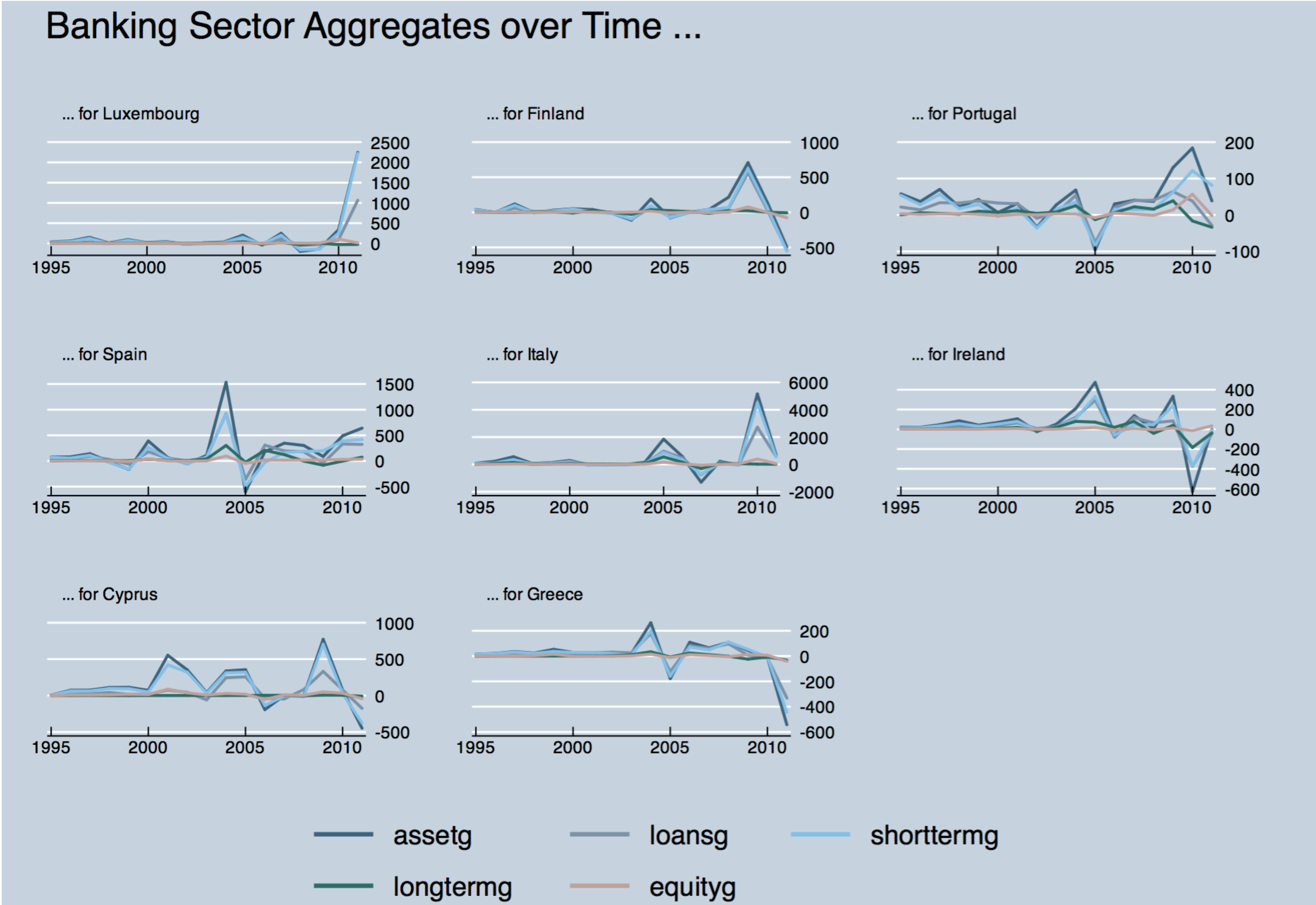
2.D Graphs



These panels show the development of major banking sector aggregates by country in billion euros over time. *assetg* stands for the absolute annual change of the banking sector's assets; *loansg* stands for the absolute annual change of the banking sector's outstanding loans; *shorttermg* stands for the absolute annual change of the banking sector's short-term funding (less than one year); *longtermg* stands for the absolute annual change of the banking sector's long-term funding; *equityg* stands for the absolute annual change of the banking sector's equity.

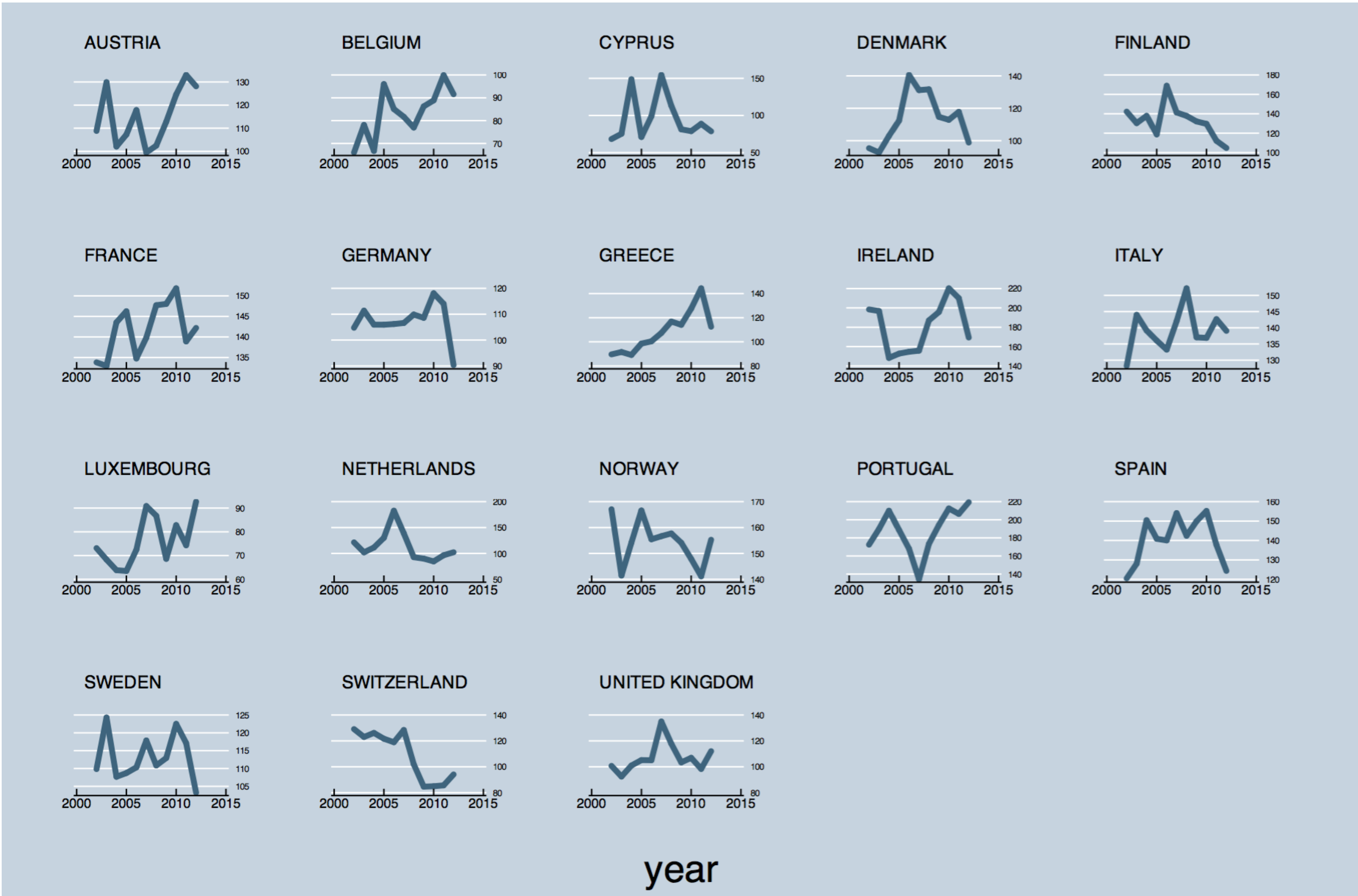
FIGURE 2.14: Abs. change of banking sector aggregates by country over time

FIGURE 2.15: Abs. change of banking sector aggregates by country over time cont'd



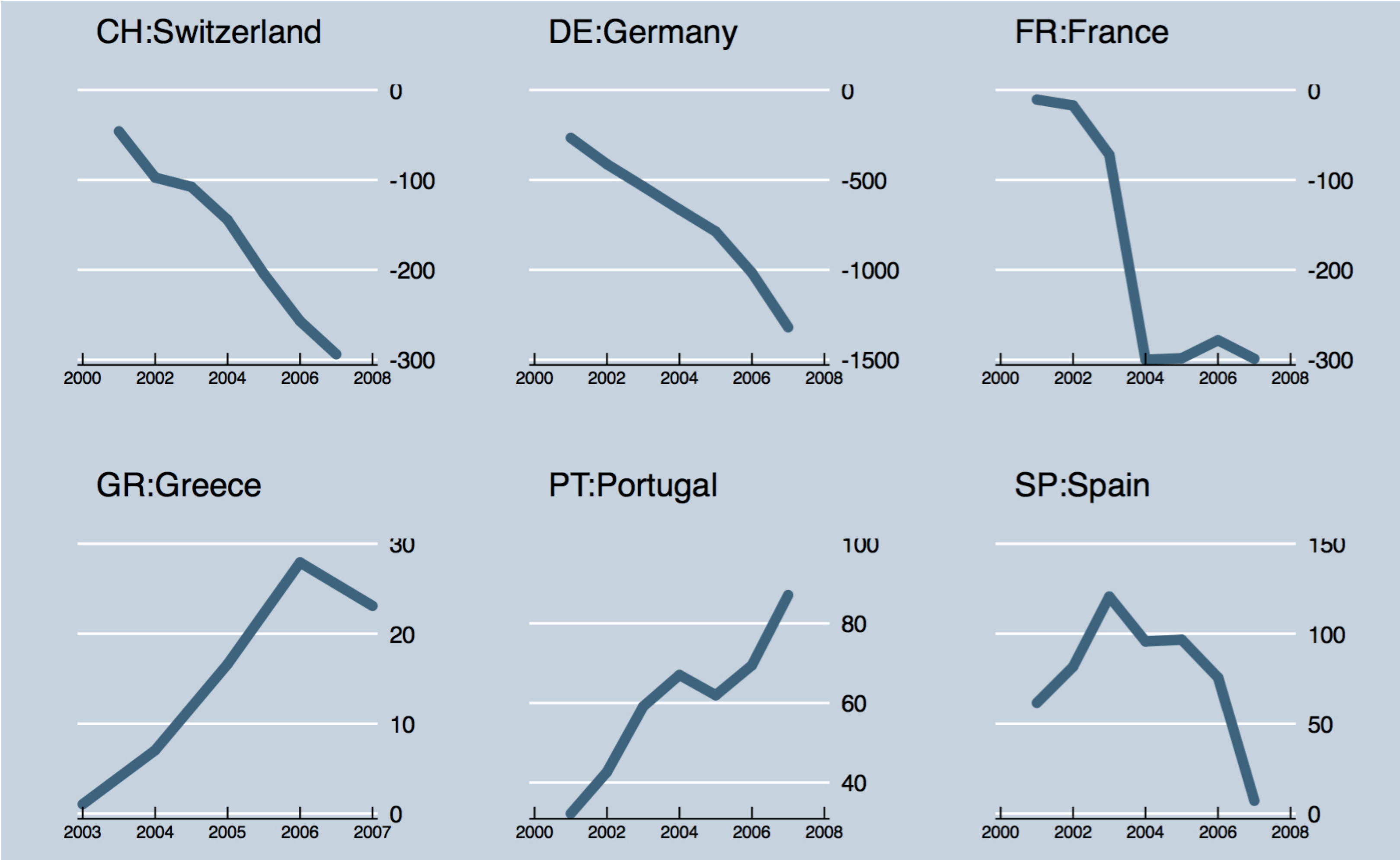
These panels show the development of major banking sector aggregates by country in billion euros over time. *assetg* stands for the absolute annual change of the banking sector's assets; *loansg* stands for the absolute annual change of the banking sector's outstanding loans; *shorttermg* stands for the absolute annual change of the banking sector's short-term funding (less than one year); *longtermg* stands for the absolute annual change of the banking sector's long-term funding; *equityg* stands for the absolute annual change of the banking sector's equity.

FIGURE 2.16: Average loans to deposit ratio of commercial banks by country over time

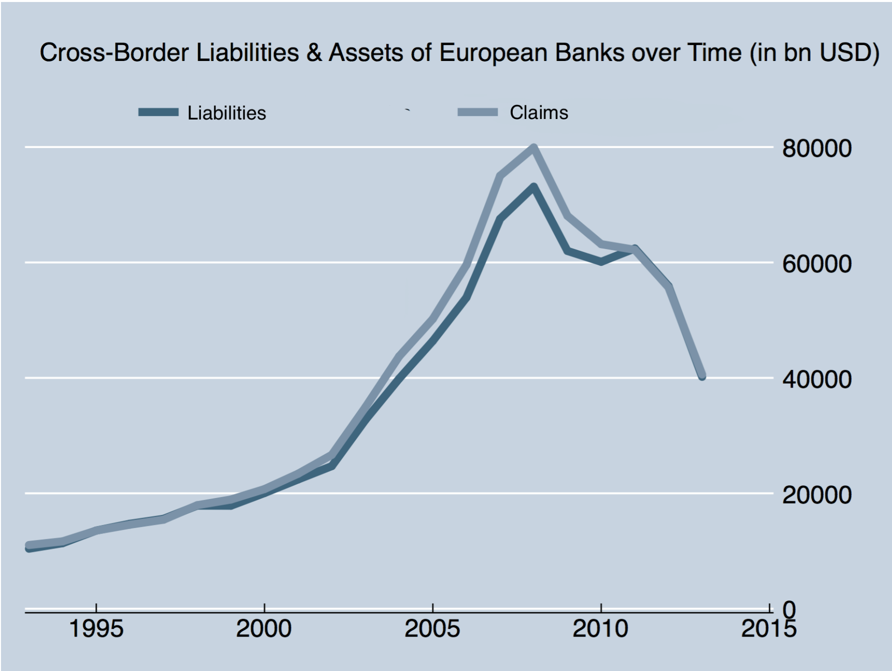


These panels show the development of the loan-to-deposit ratio by country over time; the ratio increased strongest in the euro area's periphery in the run-up to the recent crisis, as deposit growth could not keep pace with banks' investment opportunities.

Figure 2.17: Net foreign capital pos. of selected banking sectors over time (bn USD)

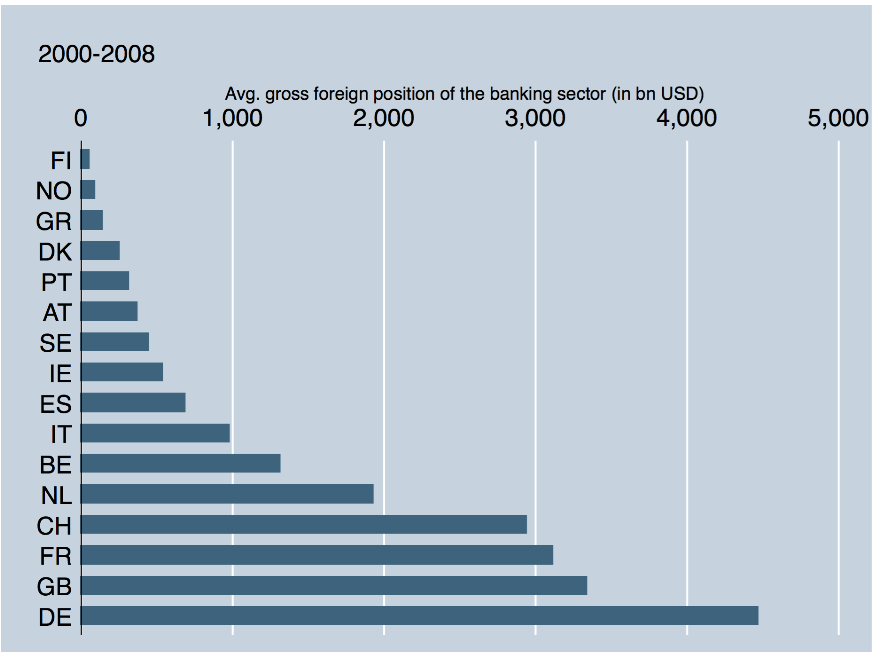


These panels show the development of net foreign capital position of selected banking sectors by country in billion euros over time. The net foreign capital position is defined as a banking sector's liabilities to foreign banks minus claims against foreign banks. They show that, in the run-up to the crisis, banks in Switzerland, Germany, and France were lending on the interbank market to their peers in Greece, Portugal, and Spain.



This figure illustrates the aggregate increase of the sum of cross-border assets and liabilities of the European banking sector between 2000 and 2008 in billion USD. The cross-border exposure of European banks increased five fold between 1999 and 2008; followed by a sudden drop during the crisis.

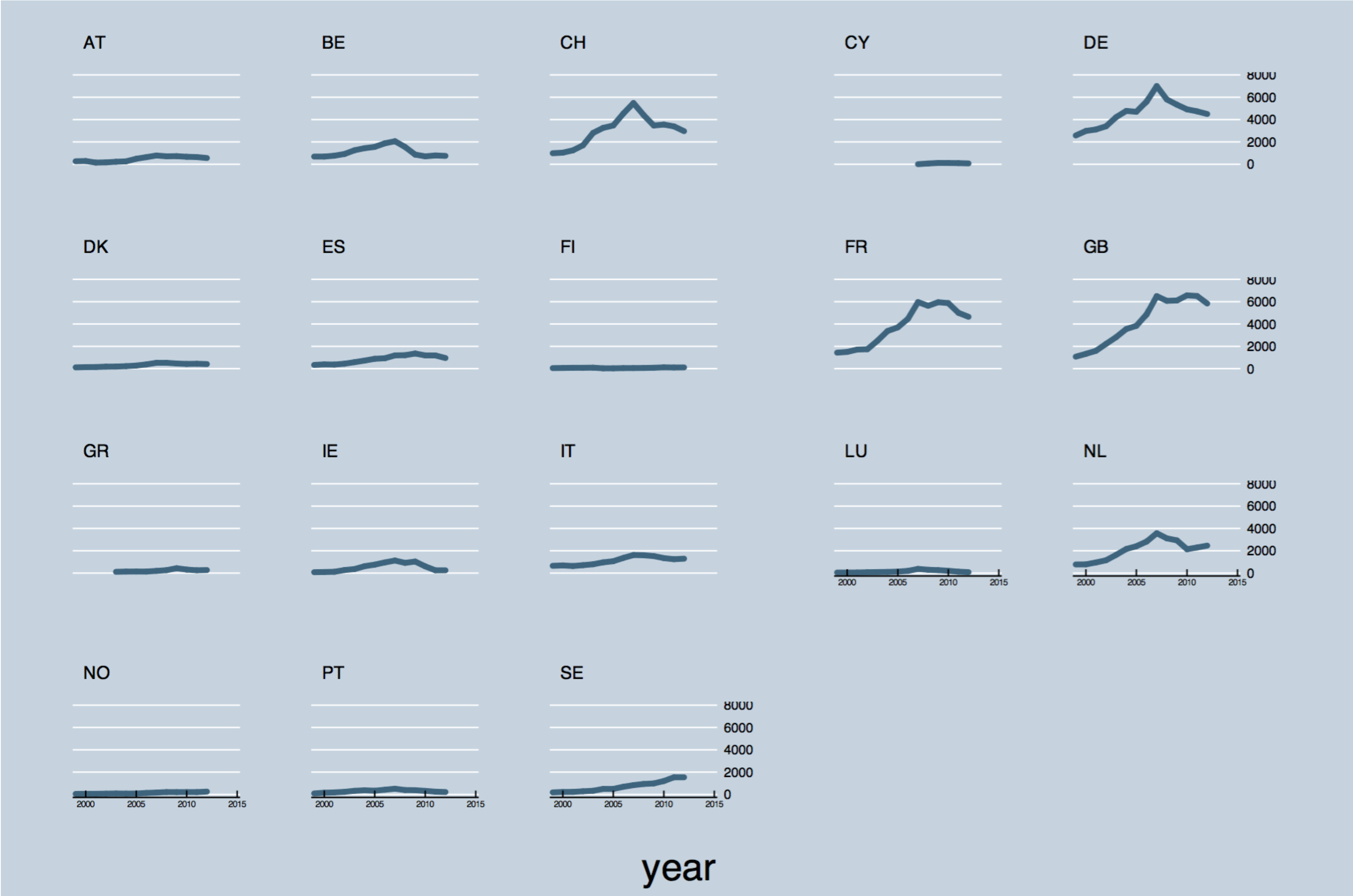
FIGURE 2.18: Cross-border assets and liabilities of European banks on aggregate



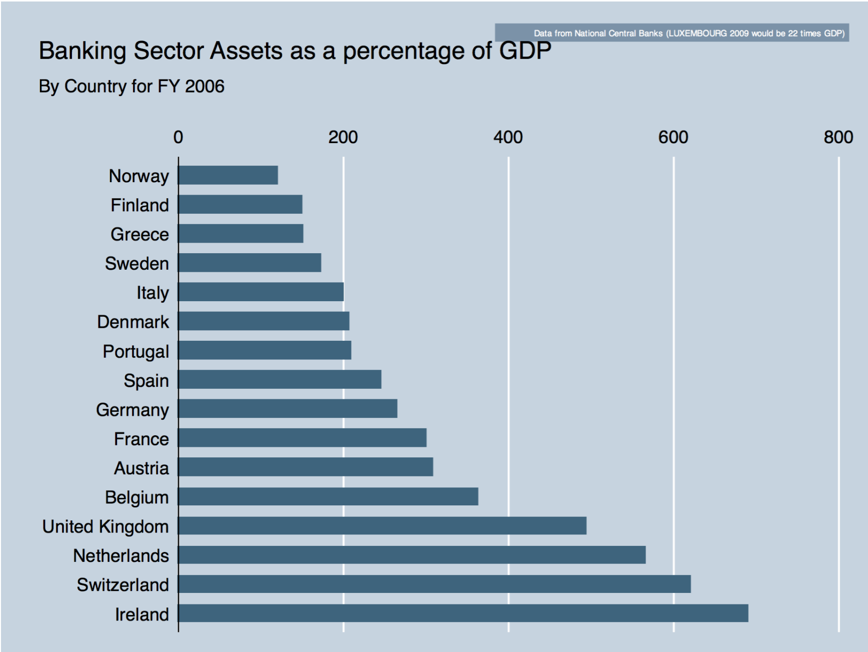
This figure illustrates the aggregate increase of the sum of cross-border assets and liabilities of European banking sectors by country between 2000 and 2008 in billion USD. German, British, French, and Swiss institutions are central hubs in the European banking system.

FIGURE 2.19: Cross-border assets and liabilities of European banks by country

FIGURE 2.20: Gross foreign pos. of the banking sector by country over time (bn USD)

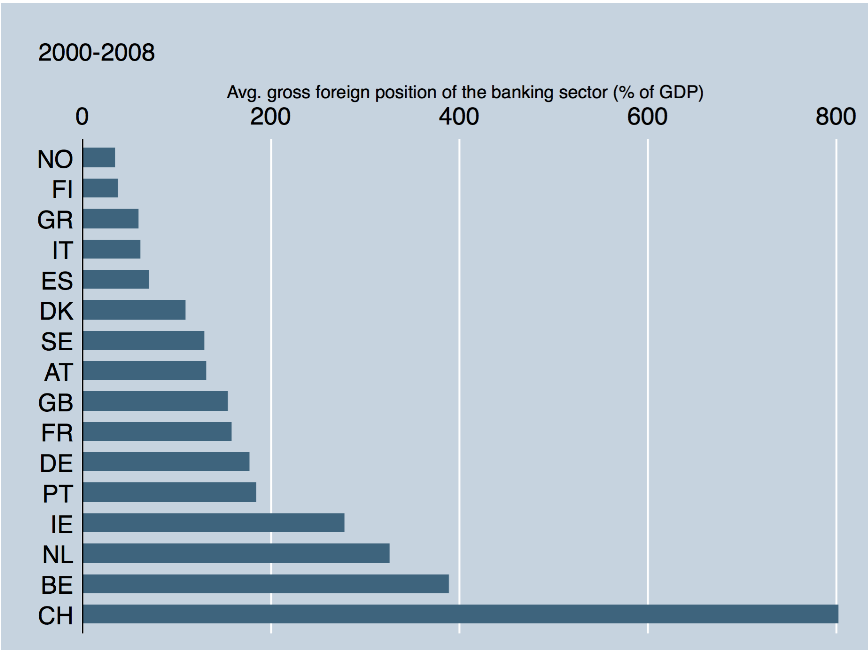


These panels illustrate the increase of the sum of cross-border assets and liabilities (gross position) of European banking sectors in billion USD by country over time. German, British, French, and Swiss institutions are central hubs in the European banking system.



This figure illustrates the ratio of banking sector assets to GDP by country in 2006. Ireland, Switzerland, the Netherlands and the United Kingdom feature the biggest banking sectors in relation to their GDP.

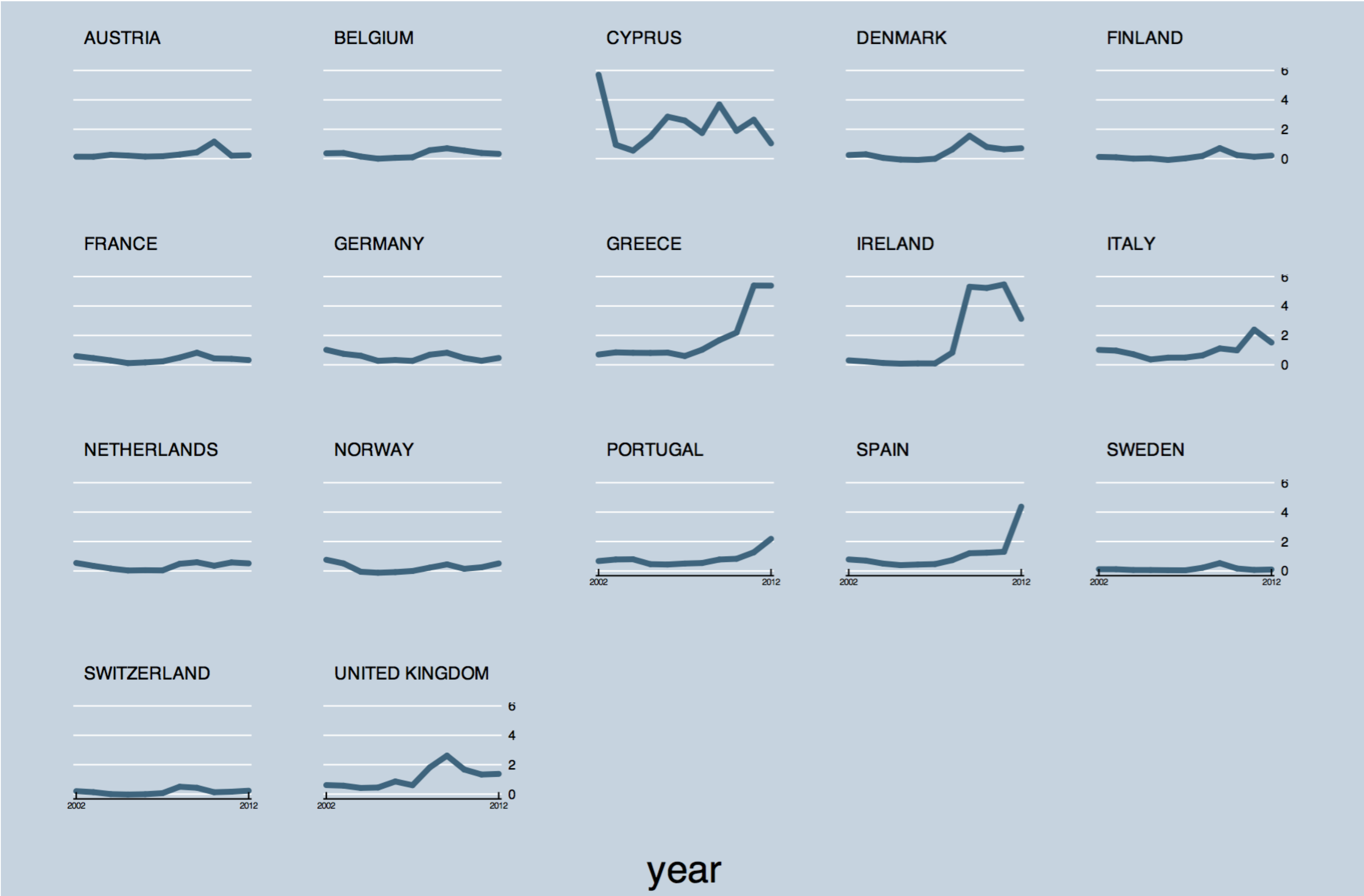
FIGURE 2.21: Banking sector assets to GDP by country for 2006



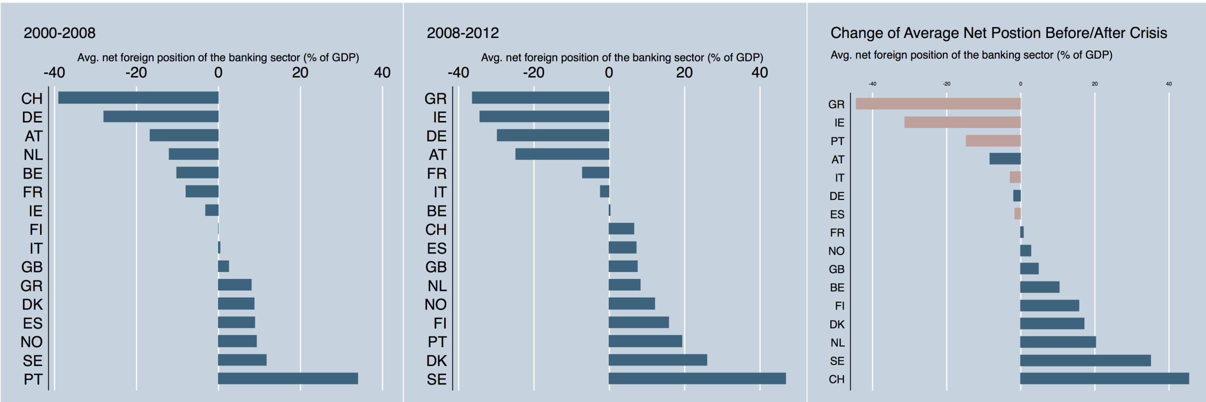
This figure illustrates a banking sector's average foreign gross position, i.e. the banking sector's liabilities to foreign European banks plus foreign claims, between 2000 and 2008 as a ratio to GDP. The Swiss banking sector is by far the most internationally connected in relation to its GDP. Belgium, Dutch, and Irish banks are well strongly interwoven with their peers in other European countries as well.

FIGURE 2.22: Average gross foreign position of the banking sector as a ratio of GDP

FIGURE 2.23: Loan loss prov. of European banks by country over time (% of total assets)

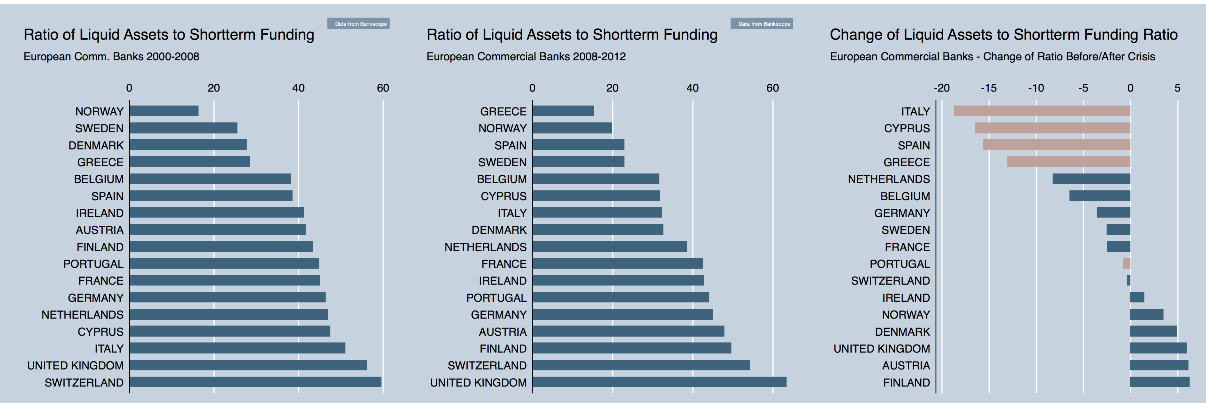


These panels show the development of loan loss provision of European banking sectors by country over time as a percentage of total assets. Loans loss provisions increased strongest in the GIIPS (Greece, Ireland, Italy, Greece, and Spain) as well as in Great Britain.



This figure shows the average net foreign position of the banking sector as a percentage of GDP by country before (first panel) and during (second) the crisis and the change in percentage points. The GIIPS are marked in orange and feature the biggest negative changes of that ratio.

FIGURE 2.24: Average net foreign position of the banking sector as a percentage of GDP



This figure shows the average ratio of high quality liquid assets to short-term debt for European commercial banks by country before (first panel) and during (second) the crisis and the change in percentage points. The GIIPS are marked in orange and feature the biggest negative changes of that ratio.

FIGURE 2.25: Avg. ratio of liquid assets to short-term debt for European comm. banks

(A) Eligible for HQLA	with factor
Marketable securities from sovereigns and central banks	100%
Domestic sovereign debt for non-0% risk-weighted sovereigns	100%
Corporate debt securities rated between A+ and BBB-	50%

(B) Assessment of potential outflows for different forms of funding	Prob. of outflows
Non-financial corporates, sovereigns, and central banks	40%
If covered by deposit insurance scheme	20%
Operational deposits generated from clearing and cash management	25%
If covered by deposit insurance scheme	5%

TABLE 2.6: Basel Committee's remarks on its liquidity measures

2.E Data sources

Source	Figures/Tables	Retrieved
Bankscope	Figures 2.25, 2.22 (a), 2.14, 2.15, 1.2, 2.16 , 2.23	October 2013
Bank for International Settlements Locational Statistics	Figures 2.17, 2.1, 2.19, 2.24, 2.22 (b), 2.20	November 2013
Capital IQ	Tables 2.4 et seqq.	November 2013

Chapter 3

European Business Cycle Co-Movement: The Role of Unit Labor Costs

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4 The paper has been presented at the Meeting of the Royal Economic Society in Manchester (UK), the Conference of the Western Economic Association in Denver (USA), the Joint Accounting/Finance Seminar at Stanford Graduate School of Business (USA), the Austrian Central Bank, and the Economics Seminar at the University of Innsbruck (AUT).
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Abstract

The European debt crisis reminded us that some member countries of Economic and Monetary Union (EMU) experienced unsustainable pre-crisis booms accompanied by an increase in wages far beyond what would have been justified by long-lasting trends in labor productivity. Within a currency union, such diverging trends in wages and competitiveness cannot be mitigated by simply adjusting nominal exchange rates. Against this background, it is astonishing that the impact of labor cost dynamics on business cycle co-movement – the most widely used meta-criterion for an optimum currency area – has not been analyzed so far. In our empirical analysis, we reveal a highly significant and policy-relevant finding: While wage developments do not affect business cycle convergence outside a currency union, wage growth differentials across countries significantly reduce business cycle co-movement within a common currency area. The economic significance of the effect is surprisingly large and even exceeds the impact of bilateral trade relations.

JEL classification: E31, E32, F44
Keywords: *Business Cycle Synchronization, Unit Labor Costs, Competitiveness, Currency Union, Optimum Currency Area*

'The principal danger ... in participating in a fixed exchange rate area arises from the certainty, in the absence of perfect competition in product and factor markets, that developments would occur from time to time that pushed the relative cost levels of the participating countries out of line' (Fleming, 1971)

'I believe that the single most important problem is the divergent trend of unit labor costs in Europe.' (Keuschnigg, 2012)

'EMU is a gamble that can be won in the long run only if it overcomes the existing political stasis to force fundamental fiscal and labor market reform in its member states. If Europe's leaders cannot do an end run around domestic opposition in the name of European integration, EMU could prove unstable.' (Obstfeld, 1997)

'... We must be concerned about the implications of the lack of an exchange rate mechanism... If exchange rates were flexible, these differences in inflation rates would by and large be reflected in exchange rate movements. Anticipation of exchange rate movements would force nominal interest rates to be different in different countries ... When nominal interest rates are the same, however, differences in inflation rates induce differences in real interest rates. In countries with higher inflation rates, real interest rates are lower, and, ceteris paribus, investment demand will be higher. Higher investment in turn boosts aggregate demand, which contributes to rising prices' (Hellwig, 2011)

'... one monetary policy for all cannot work' (Gikas Hardouvelis, Finance minister of Greece, NZZ (2014))

3.1 Introduction

The European debt crisis and the associated threat of a possible break-up of the euro area have put the topic of optimum currency areas and their preconditions back to the very center of the political and economic discourse. In response to the crisis, European policy makers recognized that the economic coordination process among members of Economic and Monetary Union (EMU) would have to be strengthened in order to avoid future tensions on debt markets, to forestall internal imbalances and to assure the proper functioning of the common currency area in general. Indeed, several steps in this direction have already been undertaken. The introduction of the European Semester to coordinate economic policies and national budget plans, the installation of a European Systemic Risk Board to ensure a healthy financial sector and the initiation of the Banking Union exemplify the trend towards intensified economic coordination.[6] These measures are essentially based on the ideas of the optimum currency area (OCA) literature, which has been proclaimed almost half a century ago. The first contributions in this field of research were mainly theoretical studies, which proposed a broad set of prerequisites for a successful integration of member states such as (i) price and wage flexibility (Friedman, 1953), (ii) mobility of factors of production including labor (Mundell, 1961), (iii) financial market integration (Ingram, 1962), (iv) similarities of inflation rates (Fleming, 1971), (v) fiscal integration (Kenen, 1969) and (vi) a high degree of economic openness (McKinnon, 1963).[7] All these criteria were intended towards harmonizing economic developments among member states and thereby lowering the costs associated with relinquishing the potential compensation mechanisms of sovereign monetary policies.

While the empirical literature has devoted increased attention towards these factors in recent years, a consensus on their relative importance for the proper functioning of EMU is yet to be reached. The most widely used criterion to assess their relevance and to judge whether economies are suited to form a currency union is the degree of synchronization among their business cycles (BC).[8] The underlying argument is simple: If business cycles in countries within a monetary union diverge, a common monetary policy will not be optimal for all countries concerned (Bayoumi and Eichengreen, 1997; Masson and Taylor, 1993). Recent events and the introduction of EMU thus spurred renewed interest in the topic and – based on the aforementioned BC synchronization concept – several factors have been suggested to determine cyclical co-movement. While the positive effect of bilateral trade relations on business cycle synchronization is now firmly established in the literature (Artis and Okubo, 2011; Inklaar et al., 2008;

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6 For an overview on all new measures taken by the EU and its member states see: `http://ec.europa.eu/economy_finance/economic_governance/index_en.htm`.

7 See Mongelli (2002) and Mongelli (2008) for a detailed review of OCA theory and evidence.

8 See de Haan et al. (2008) for a broad literature survey on empirical papers exploring determinants of business cycle synchronization and its development over time in the European context.

Baxter and Kouparitsas, 2005; Frankel and Rose, 1998; Gächter and Riedl, 2014), the jury is still out on other determinants. Darvas et al. (2005), for instance, highlight the importance of fiscal variables such as budget deficits and public debt while Imbs (2004) stresses the relevance of financial integration. Gächter and Riedl (2014) show that EMU membership *per se* has increased BC synchronization across member countries. Yet, one factor that has been prominently discussed both in the theoretical literature and in policy circles has been disregarded in empirical studies so far: the impact of labor market developments such as unit labor costs.

At first glance, the impact of wage growth differentials on business cycle co-movement is theoretically ambiguous. On the one hand, wage flexibility is considered one of the most important prerequisites for countries to join a currency union, in order to be able to adjust to both internal and external imbalances. In the case of an asymmetric exogenous demand shock, wage dispersion is necessary to move back to equilibrium, and would therefore increase business cycle co-movement. On the other hand, however, wage dispersion (and corresponding inflation differentials) can also be the cause of demand shocks in individual countries, thereby acting as a disequilibrating mechanism leading to lower business cycle co-movement. While previous literature disagrees on whether higher wage growth in the periphery was caused by institutional differences in wage bargaining or rather by strong capital inflows, both strands of the literature highlight the crucial role of wage developments in fueling domestic demand booms in the euro area's periphery, while core countries exhibited significantly lower GDP growth rates due to substantial wage restraint. In this respect, the real interest rate channel additionally reinforced this effect in a vicious circle, and thus further contributed to business cycle divergence. While Fleming (1971) has already stated that *'the principal danger ... in participating in a fixed exchange rate area arises from the certainty, in the absence of perfect competition in product and factor markets, that developments would occur from time to time that pushed the relative cost levels of the participating countries out of line'*, the considerable differences in inflation rates in early years of EMU were not regarded as a major problem and were commonly interpreted as a natural catching-up process resulting from the widely known Balassa-Samuelson effect. The European debt crisis, however, eventually illustrated that this view had been far too optimistic. In fact, recent policy work on possible reforms of the EMU governance framework has highlighted wage developments as one key factor for a proper functioning of EMU (see, for instance, Sapir and Wolff, 2015). Surprisingly, however, this factor has been neglected so far in the empirical literature on optimum currency areas.

Against this background, the present paper aims at exploring whether diverse unit labor cost developments indeed exerted a negative impact on the co-movement of European business cycles. To the best of our knowledge, no other study has tackled this venture so far. While cyclical synchronization has been widely regarded as the 'meta' criterion for OCAs for long, diverging unit labor cost developments have not been suggested as a major determinant in the literature yet. The missing empirical evidence, however, may well have been a consequence of a lack of adequate econometric tools. By using novel synchronization measures as recently proposed by Cerqueira and Martins (2009) and Cerqueira (2013) as well as a dynamic panel estimator, we are able to exploit the time variability in our data sample and to handle the issue of endogeneity in an appropriate manner. Based on data for 27 European Union countries in the period 1993 to 2011, we show that differences in growth rates of NULC have been one of the most important determinants of business cycle synchronization among the group of euro countries. In contrast, the impact of labor cost developments among non-EMU members is not statistically significant, most likely due to the possibility of nominal exchange rate adjustments. Hence, the present paper constitutes an important contribution to the current policy debate in Europe on how to reform monitoring mechanisms to move EMU closer to an OCA. The empirical insight that the divergence of national unit labor costs leads to less synchronized business cycles and thus to an increase of the costs of a common currency calls for a much stronger institutional framework at the European level.

3.2 Theoretical background

3.2.1 Wage dispersion, external imbalances and the OCA theory

This section outlines the relationship between diverging wage developments and business cycle synchronization within a currency union. From a theoretical perspective, the impact of wage growth dispersion on business cycle synchronization is ambiguous. On the one hand, wage flexibility is considered one of the most important prerequisites for countries in a currency union (see, for instance, De Grauwe (2009)). By irrevocably fixing their exchange rates and adopting a common currency, members lose their control over monetary policy and the exchange rate as main adjustment instrument to internal (inflation) and external (current account and trade balances) imbalances. Thus, if one country experiences an exogenous (negative) demand shock and moves into recession, relative wage and price adjustments are the only possibility to move back to equilibrium. In the case of exogenous demand shocks, higher wage dispersion – acting as an equilibrating mechanism – might therefore increase business cycle co-movement. On the other hand, however, wage dispersion can also be the cause of demand shocks in individual countries, as relatively pronounced wage increases are likely to induce domestic demand booms. In this case, higher wage dispersion acts as a disequilibrating mechanism, leading to lower business cycle co-movement.[9]

[9] The arguments resemble the controversial debate on the impact of fiscal policy differentials on business cycle co-movement, which is also theoretically ambiguous (see, for instance, Darvas et al., 2005; Gächter and Riedl, 2014).

For the case of EMU countries, however, we subsequently argue that the latter effect outweighs the former for several reasons. Previous literature has suggested various causes for the occurrence of persistent external imbalances in the euro area. These theories can be summarized in two different views, which are not mutually exclusive, but are rather likely to reinforce each other (Johnston and Regan, 2014).

The first strand of literature argues that structural imbalances between export-led (core) countries and domestic demand-led (periphery) countries resulted in divergent wages, inflation rates and eventually competitiveness (see, for instance, Hall, 2012; Shambaugh, 2012; Johnston et al., 2014), as the nominal exchange rate is no longer available as an equilibrating mechanism in a common currency area. Thus, according to this institutional view, export-led core countries which typically exhibit corporatist wage-bargaining institutions produced significant wage moderation relative to their southern peripheral counterparts where such coordinated wage bargaining systems are non-existent. This led to low inflation and increasing current account surpluses in the core and a corresponding loss of competitiveness in the periphery. In this first view, trade and financial imbalances were therefore caused by a loss in competitiveness in peripheral countries (i.e. via the current account); financial flows from the EMU's core to the periphery followed as a consequence via the financial account.[10]

The second view, on the contrary, argues that imbalances started in the financial account, and that the loss of competitiveness was merely a consequence rather than the cause of financial imbalances (Johnston and Regan, 2014): With the convergence in nominal exchange rates and interest rates in EMU, peripheral countries experienced significant reductions in borrowing costs (Hellwig, 2011; Lane, 2012, 2013). This access to cheap credit fueled consumption and real-estate booms in the periphery, and thereby increased both wages and inflation. The appreciation of real exchange rates, which can therefore be seen as a consequence of financial inflows rather than their cause, eventually led to the observed imbalances across euro area countries.

While the two different perspectives basically constitute a chicken-and-egg problem, it seems likely that both lines of arguments have played a significant role in the euro area. More importantly, however, wage developments play a crucial role in reinforcing external imbalances in both theories, irrespective of whether wage increases were mainly due to institutional factors (i.e. differences in wage bargaining institutions) or strong capital inflows. Pronounced wage growth has fueled domestic demand booms in peripheral countries mainly via two self-amplifying transmission channels. First, higher wages increased domestic demand directly by increasing households' disposable income. Second, the increase of the inflation rate due to excessive wage

[10] External financing mainly stemmed from core countries due to a significant home bias in European investment (Gros, 2012). Thus, it is not surprising that current account deficits in the periphery were virtually mirrored by current account surpluses in the core, while the euro area as a whole exhibited a more or less balanced current account to the rest of the world prior to the crisis.

growth reduced domestic real interest rates which in turn stimulated investment and domestic demand in an indirect way and further amplified the original inflation differentials. While this real interest rate channel has hardly been considered in previous literature on the OCA theory, it acted as a self-reinforcing vicious circle which triggered further business cycle divergence.

Although the divergence in real exchange rates should theoretically cause a loss of competitiveness and weaker export performance of peripheral EMU countries which would have an equilibrating effect, empirical data suggest that the 'internal' effect (i.e. domestic demand boom) came into play instantaneously, while the 'external effect' (i.e. lower net exports) needed a considerable time span to become relevant (i.e. the widely known "J-curve" effect). The systemic circulation, which fueled domestic demand booms and external deficits, just came to a halt when the euro area was hit by the global financial crisis and the subsequent debt crisis. External financing dried up (similar to a "sudden stop" scenario) and wages started to decrease. Once again, the 'external' effect of lower wages should theoretically lead to a recovery in corresponding countries due to a real depreciation and increasing net exports. In fact, the opposite happened, because domestic demand collapsed immediately when wages decreased thereby starting a vicious circle in another direction. Following this line of reasoning, we expect a negative link between wage dispersion and business cycle co-movement because domestic demand effects are stronger and take full effect faster than external demand effects.

We furthermore argue that this self-reinforcing vicious circle could only have been interrupted by coordinating wages across EMU countries. The latter is the only policy tool with some room of manoeuvre in an environment of capital mobility and free trade within the euro area. Thus, while wage flexibility is still needed to cope with exogenous demand shocks, it must be assured that wage dispersion does not act as an endogenous demand shock, which causes asymmetric cyclical movements within a currency area. The fact that wage setting mechanisms and institutions are still under national responsibility in the EMU governance framework increases the probability of such wage-induced cost-push shocks, which tend to be further amplified by generous wage settlements in non-export oriented goods and labor market segments that are still fragmented.

3.2.2 The role of wage dispersion in EMU

A first look at the data as illustrated in figure 3.1 shows that peripheral EMU countries featured significantly higher economic growth rates than their peers in the core during the first years of the euro. These different growth paths were facilitated by domestic demand booms in the periphery (Greece, Ireland, Italy, Portugal, Spain), which were fuelled by labor compensation increases far above what would have been justified

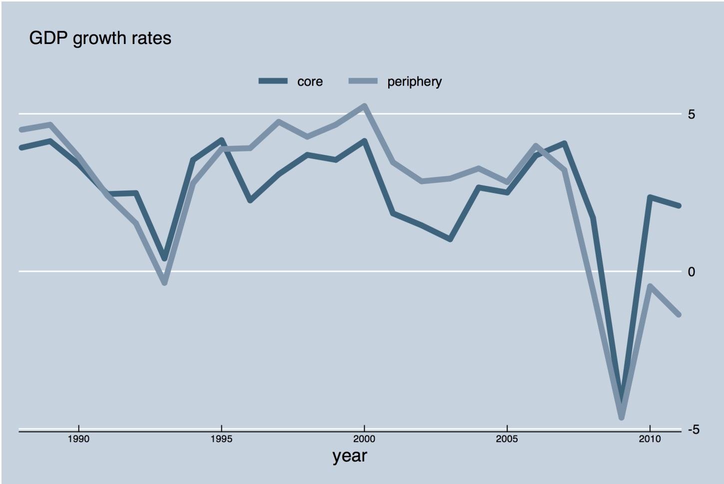


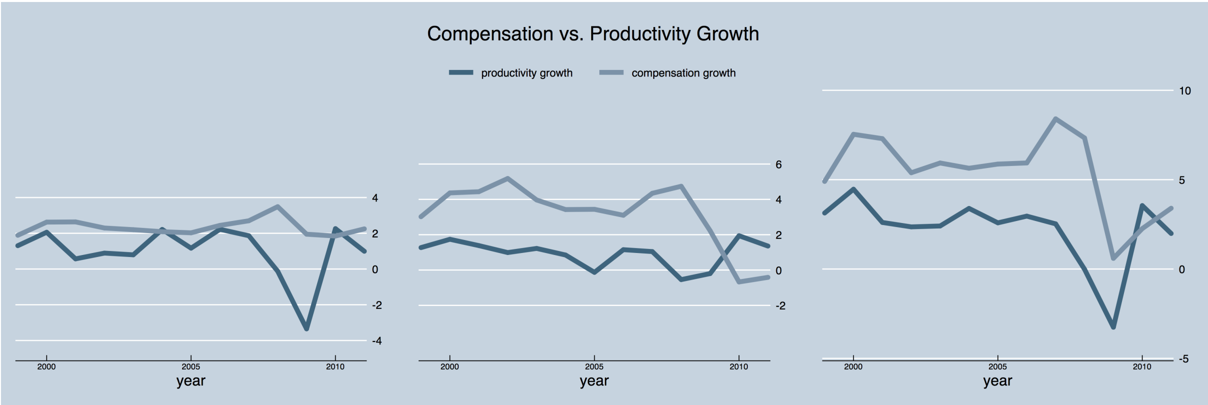
FIGURE 3.1: Average growth rates in core and peripheral EMU countries over time

by productivity improvements alone (see figures 3.2 (a) to (c)). Such generous wage settlements were possible due to the aforementioned difference in wage bargaining mechanisms and considerable capital inflows, which generated additional economic leeway. In fact, compensation versus productivity growth developments in peripheral EMU countries is very similar to that of non EMU countries, which underwent a comparable post-millennial catching-up process.

The heterogeneous dynamics of NULC – defined as labor compensation over productivity – between 2000 and 2011 are documented for selected countries in figure 3.2 (d). Nominal unit labor costs rose most strongly in non-EMU countries such as Romania, Latvia, and Slovakia. But the EA periphery also experienced substantial upward movements while wage restraint in core countries of EMU such as Austria and Germany kept them relatively low (figure 3.2 (e)).

These persistent differences eventually translated into diverging levels of inflation and real interest rates, a mechanism which has also been stressed by Lane (2006) and Hellwig (2011) and which emerges naturally within a monetary union, where there is only one common nominal interest rate set by the ECB. The relatively low real interest rates in the periphery right up to the onset of the crisis are illustrated in figure 3.3 (a). Following the formal logic of the arguments discussed, this stimulated demand (as well as credit growth and housing markets) in high inflation countries. This euphoria in turn induced periphery countries to raise wages faster than productivity dynamics would have justified. These generous wage settlements provoked wage-driven inflation and lowered real interest rates even further. A vicious circle of further divergence emerged. Keuschnigg (2012) and Hellwig (2011) argue that these effects were furthermore accentuated by an important capital market failure, which essentially made nominal interest rate differentials in the euro area disappear. This observation is indeed evident from figure 3.3 (b).

(A) core (B) periphery (C) non EMU



(D) (E)

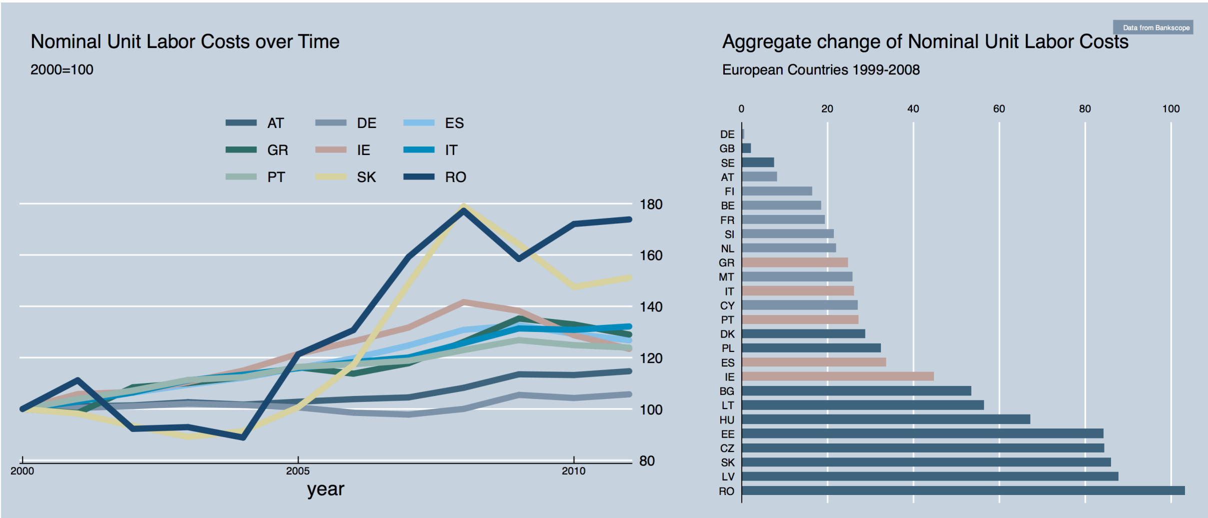


FIGURE 3.2: Nominal unit labor costs in Europe (2000=100)

(A) (B)

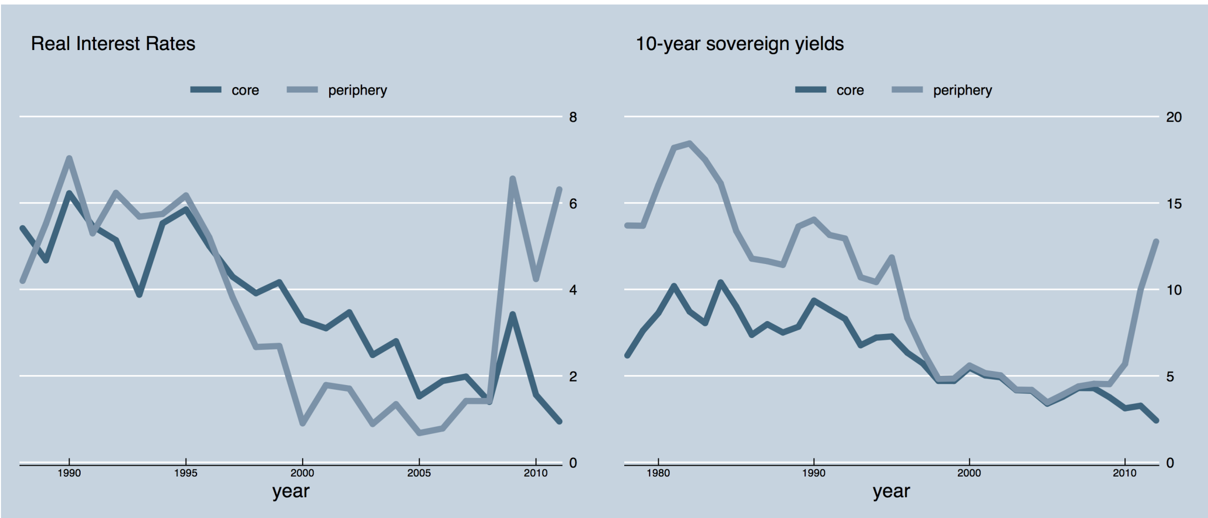


FIGURE 3.3: Avg. real interest rates and avg. sovereign yields (10-year bonds) over time

Hence, public debtors in Europe's periphery were tempted by excessively low levels of interest rates on public debt, borrowed well above what would have been justified by underlying real developments and boosted the economy with additional stimulus. Lane (2006) also highlights that the sizeable differences of average inflation rates over the first six years of EMU (1999–2004) were particularly distinct in the non-tradable services sector, which also supports the domestic boom narrative in the periphery.[11] Due to the country's subdued wage-setting, Germany experienced weak domestic demand, relatively low inflation rates and modest economic growth during the same period. The link between the increase in NULC and (cumulative) real GDP growth is shown in the left-hand chart of figure 3.4. The positive correlation between the two variables is clearly visible for the EA-12 sample, with Germany and Ireland at the extremes. This graphical evidence thus suggests that diverging wage developments triggered considerably less synchronized growth paths within EMU in this early period, i.e. generous wage settlements in the periphery may have facilitated local booms by stimulating domestic demand while the opposite holds true for core countries. Due to the Great Moderation, which guaranteed comparatively stable (global) external demand in the first years of EMU, however, cyclical co-movement remained relatively high initially.

Over time, though, wage-driven inflation continuously pushed-up the periphery's production costs. Real exchange rates therefore steadily appreciated. Portugal, Ireland, Italy, Greece and Spain alike suffered a considerable erosion of their price competitiveness as compared to core countries of the euro area thus building up substantial current account deficits. The latter point is plainly illustrated in the right-hand panel of figure 3.4, which again features Germany and Ireland on opposite ends of the distribution.

While these decreasing export shares had been covered up by their domestic booms for long, the eruption of the crisis and the associated dry-up of external financing revealed the imbalances virtually overnight. In conjunction with the challenges in the banking sector and escalating levels of sovereign debt, these effects triggered doubts about the countries' economic viability as well as abrupt capital outflows, leading to a correction of NULC paths (see figure 3.2). The phenomenon was further accelerated by a sharp decline of global demand and the fact that national sovereigns could no longer provide the necessary public stimulus. Debt levels were already too high and new bond issues became excessively expensive for peripheral countries, when their risk premia suddenly shot up (figure 3.3). While these adverse dynamics may be mitigated by corresponding adjustments of the (nominal) exchange rate outside a common

[11] Inflation differentials as a result from catching-up developments (i.e. due to the Balassa-Samuelson effect) would emanate from the tradable (due to rapidly increasing productivity) to the non-tradable sector (which has less productivity gains). The empirical pattern in early years of EMU showed a reversed sequence, once again highlighting the domestic demand boom.

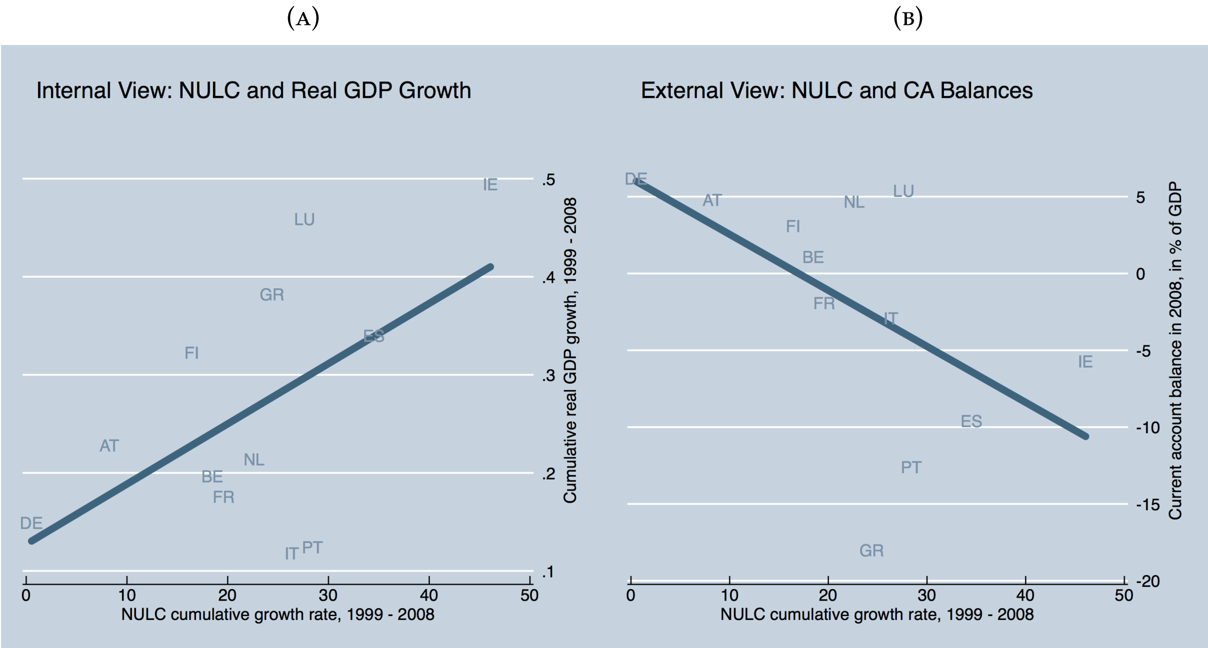


FIGURE 3.4: The internal and external view

currency area, they may cause substantial tensions within a currency union. The same factors that had initially facilitated the booms now proved to cause recessionary (deflationary) effects, as the loss of competitiveness and the dry-up of external funding led to decreasing wages and thus caused a collapse in domestic demand. It therefore seems obvious that diverging trends of unit labor costs eventually lead to asymmetric business cycles. For this reason, we suggest that NULC developments might be an important determinant of business cycle synchronization, particularly so in a common currency area like EMU.

3.3 Data and measurement issues

3.3.1 Business cycle synchronization

Following Gächter and Riedl (2014), the empirical analysis considers a slightly adapted version of the synchronization index proposed by Cerqueira and Martins (2009) and Cerqueira (2013) to measure the co-movement of two countries' time series $c_{j,t}$ and $c_{i,t}$, i.e.,

$$\text{Correl}_{ij,t} = \frac{1}{2} \log \left(\frac{1 + \frac{\rho_{ij,t}}{2T-3}}{1 - \rho_{ij,t}} \right) \tag{3.1}$$

where

$$\rho_{ij,t} = 1 - \frac{1}{2}\left(\frac{c_{j,t} - \bar{c}_j}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(c_{j,t} - \bar{c}_j)^2}} - \frac{c_{i,t} - \bar{c}_i}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}(c_{i,t} - \bar{c}_i)^2}}\right)^2 \quad (3.2)$$

We deviate from the approach by Cerqueira and Martins (2009) in the sense that $c_{i(j),t}$ reflects the cyclical component of real GDP[12] rather than GDP growth rates. Hence, $\text{Correl}_{ij,t}$ measures the correlation of output gaps between country i and country j at each single point in time t.[13] This is an important distinction as our sample includes two very heterogeneous country groups, i.e. industrialized nations as well as former communist countries. Since these groups exhibit substantially different and changing trend growth rates the correlation between output gaps is also likely to differ from the correlation of GDP growth rates. Output gaps are also the relevant indicator from a monetary policy perspective. We therefore extract the cyclical component from GDP level data by applying the Hodrick-Prescott (HP) filter (Hodrick and Prescott, 1997). This filtering technique is the most commonly used method, which makes our outcomes more comparable to other studies. As a standard procedure for yearly observations the trend smoothing parameter is set to 6.25 (see Ravn and Uhlig, 2002). For our robustness checks, however, we intend to test the sensitivity of our results with respect to another filtering technique. In particular, we also use the Baxter-King band-pass filter[14] as suggested by Baxter and King (1999), although results of others studies proved to be rather insensitive to the choice of filtering methods (see, for example, Gruber (2010)).

It is noteworthy that this index allows us to fully exploit the time variability of our data set, which is a major advantage compared to other econometric methods. It distinguishes between specific episodes of asynchronous behavior and periods of highly positive cyclical correlations, while its mean over time corresponds to the conventionally applied correlation coefficient, i.e., $\frac{1}{T}\sum_t \rho_{ij,t} = \rho_{ij}$ with $\rho_{ij} = \frac{Cov(d_i,d_j)}{\sigma(d_i)\sigma(d_j)}$. Employing this index sets us apart from earlier research and allows us to employ a dynamic panel approach to optimally capture the dynamic developments in Europe

12 We use real GDP data (in euro) of 27 EU Member States (i.e. EU 28 excluding Croatia). As GDP data for some former communist countries are available only from 1993 onward, the subsequent estimations are restricted to the period 1993 to 2011. However, estimates for the output gap are based on the maximum available time span within the range 1988 to 2011. All data are extracted from Eurostat's online database and are therefore comparable across countries as well as over time. The number of observations for the synchronization measure amounts to 6669 ($\frac{N\times(N-1)}{2}$ country pairs, with $N = 27$ being the number of countries, which are observed for $T = 19$ years).

13 Equation 3.1 shows the transformation of the correlation measure $\rho_{ij,t}$ proposed by Cerqueira (2013) to yield a symmetric range of the index (i.e. between $-\infty$ and $+\infty$) as the measure given in equation 3.2 is bounded between $3 - 2T$ and 1.

14 It admits periodic components between two and eight years, with lead-lag length of the filter being K=3. Thus, we lose three years at the beginning and the end of our sample. Due to the availability of real GDP data before this time period, however, this will impose no constraint at the beginning of our sample.

within the given time span. After all, countries joined EMU at different points in time, the financial crises hit countries to varying degrees, fiscal limits defined in the Maastricht Treaty were severely violated, and, most importantly, the degree of business cycle synchronization varied quite considerably over time. Given that the correlation measure is available on a yearly basis, there is also no need to choose arbitrary time spans as it is done in numerous other studies. This restriction often constrains empirical studies to pure cross-sectional estimates or forces them to sacrifice parts of the time dimension by computing correlation coefficients for non-overlapping windows such as Gruber (2010). Furthermore, the autocorrelation issues associated with the application of overlapping window spans and the loss of observations can be circumvented.[15]

Table 3.1 shows that average BC correlation has been generally higher among EMU countries than for EMU/non-EMU and non-EMU/non-EMU country pairs.[16] For both groups, the average pair-wise correlation index across country-pairs has increased until the recent crisis. After 2008, however, BCs became severely less synchronized as the turmoil exerted very heterogeneous impacts on different countries. Interestingly, this was especially true among EMU members, whose average bilateral correlation index fell below the non-EMU group for the first time in the period under review.[17] The corresponding numbers are shown in table 3.1 and figure 3.5, respectively.

TABLE 3.1: Average pair-wise correlation index

	1999-2002	2003-2007	2008-2011
EMU	0.844	0.893	0.609
non-EMU	0.652	0.773	0.646

3.3.2 Labor cost variable

The labor cost dynamics described in section 3.2.2 and their impact on BC synchronization are the major focus of the empirical investigation. Unit labor costs are a measure of the average cost of labor per unit of output. More specifically, we use nominal unit labor costs (NULC) given that they adequately indicate inflationary pressures caused by rising wages (see e.g. Bellak et al., 2008). They are provided by the European Commission for almost all EU countries since 1993 and are calculated as the ratio of compensation per employee (in nominal terms, obtained from national accounts) to real GDP per person employed.[18] An alternative measure would be real

15 For a more detailed discussion of the synch. index and its advantages see Gächter and Riedl (2014).

16 EMU/non-EMU and non-EMU/non-EMU are subsumed into 'non-EMU' subsequently

17 Business cycles of selected countries and their correlation measure with Germany – as measured by the bounded index (eq. 3.2) – are graphically illustrated in figures 3.8 (a) to (d). The variations over time and across country pairs are substantial.

18 Source: Ameco database `http://ec.europa.eu/economy_finance/ameco`.

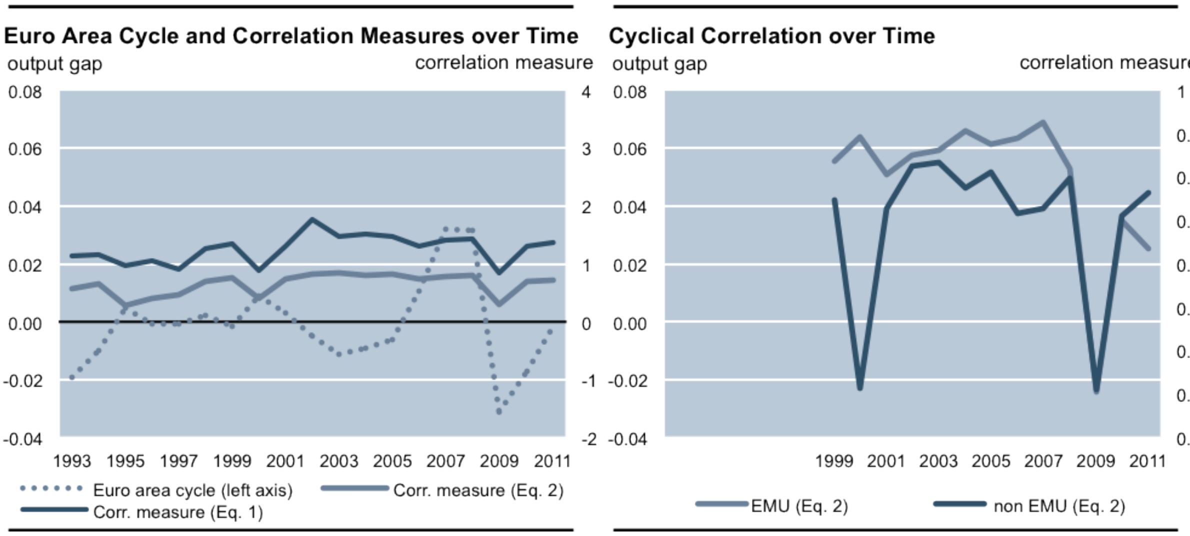


FIGURE 3.5: Euro area cycle and correlation measures over time

unit labor costs, which are calculated as nominal compensation per employee over nominal GDP per person employed. It thus reflects the wage share in the value added of an economy, which, however, makes it more of a profitability measure, which is not directly relevant for our purpose. Since we are interested in the dynamics of labor cost developments between countries (i and j), we take the absolute difference of the growth rate of nominal unit labor costs for all country pairs over time, which we denote by Labor costs$_{ij,t}$, or in formal terms

$$\text{Labor costs}_{ij,t} = |\dot{nulc}_{i,t} - \dot{nulc}_{j,t}| \tag{3.3}$$

with $\dot{nulc}_{i(j),t} = \frac{nulc_{i(j),t} - nulc_{i(j),t-1}}{nulc_{i(j),t-1}} * 100$. It is noteworthy that developments in NULC across EU member countries are used by the European Commission as one of eleven competitiveness indicators[19] which are monitored on a regular basis in the context of the Macroeconomic Imbalances Procedure (MIP). Since the financial crises it has been recognized that sustained divergence of economic competitiveness creates enormous imbalances and constitutes a considerable risk, especially within a currency union. Going forward, the Commission will thus identify member states for which certain developments are considered to warrant further in-depth analysis. The underlying mechanism in place is based on a scoreboard of indicators, amongst them the three-year change of nominal unit labor costs. The threshold above which this measure signals potential risks amounts to 9% for EMU members and 12% for non-members. Figure 3.6 illustrates that this monitoring mechanism would have been triggered on numerous occasions in the past for some peripheral countries.

19 A detailed list of the indicators is available at `http://ec.europa.eu/economy_finance/economic_governance/documents/alert_mechanism_report_2013_en.pdf`

FIGURE 3.6: Three-year NULC growth rates for selected countries

The absolute bilateral differences of NULC growth between EU country pairs, which we use for our estimates, are particularly interesting in the euro area context since our approach reflects differentials on an annual level and thus fully captures the divergence element of labor cost developments over time. Interestingly, the absolute annual bilateral differences are relatively high on average. In fact, the sample mean amounts to 7.7 percentage points as documented in table 3.2. The mean differences are considerably smaller among EMU countries as compared to countries outside EMU. This significant difference, however, is not surprising if one takes into consideration that former communist countries have experienced a remarkable catching-up process in the period under review, especially so in the mid 1990s. The full dynamics of the growth process of NULCs in levels and in absolute bilateral differentials – for peripheral as well as core countries – are highlighted in figures 3.7 (a) and (b), respectively. The spikes and dips towards the end of our sample indicate the sizeable and heterogeneous adjustments during the financial crisis.

TABLE 3.2: Labor cost variables

Variable	Full sample	Non-EMU	EMU
Labor costs$_{ij,t}$	7.70	8.84	2.13
Compensation per employee$_{ij,t}$	10.58	12.41	2.00
No. of observations	6,048	4,983	1,065

Differences in growth rates - sample averages for country pairs (in percentage points), 1993-2011.

In table 3.2 we also present the corresponding descriptive statistic for growth differences of absolute labor costs, measured as compensation per person employed (i.e., the nominator of NULC). This variable reflects labor cost differences when productivity is not accounted for. Unsurprisingly, growth differences in absolute labor costs are

(A) (B)

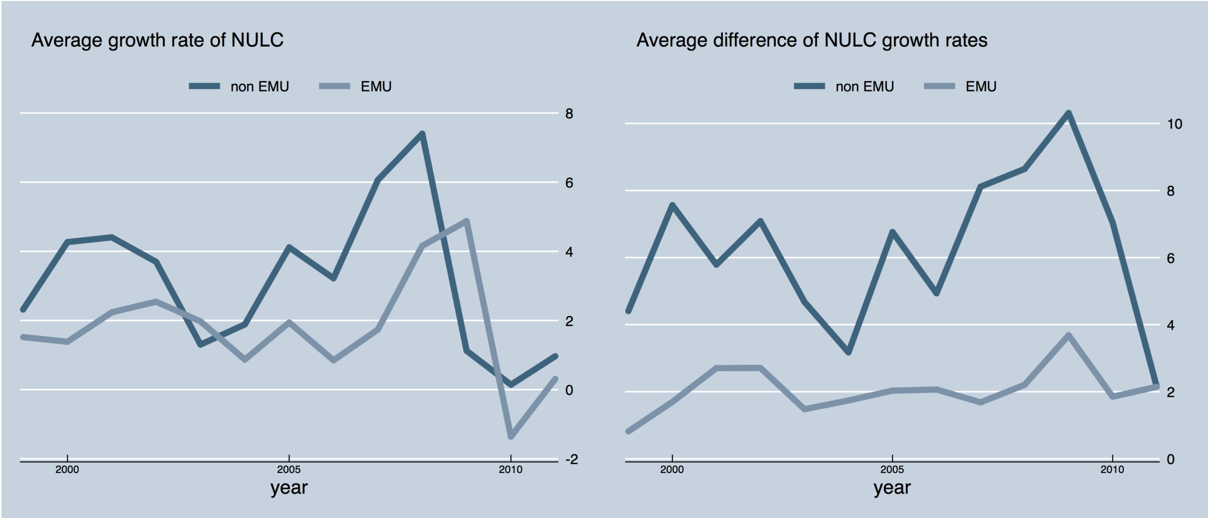


FIGURE 3.7: Avg. NULC growth and avg. absolute bil. NULC differentials over time

even more heterogeneous across different country groups. Although we consider unit labor costs to be the relevant measure for our purpose we will subsequently employ absolute labor costs as a robustness check.

Finally, table 3.3 reports some first descriptive results for the relationship between labor cost dynamics and cyclical synchronization. Simple partial correlation coefficients for both labor market measures indeed suggest that diverging labor cost developments impacted negatively on countries' business cycle co-movement. Moreover, the impact seems to be significantly higher for countries that share the euro as reflected by the interaction term between EMU membership and labor costs. Whether this is a causal effect and whether the relationship still holds when other relevant variables are controlled for, will be comprehensively examined in section 3.5.

TABLE 3.3: Partial correlation coefficients for business cycle synchronization

	nominal unit labor costs	compensation per employee
Labor costs	-0.04***	-0.10***
Labor costs × EMU	-0.05***	-0.07***
EMU	0.09***	0.10***

3.3.3 Control variables

In order to show that labor cost divergences indeed exert an influence on business cycle co-movement we employ several control variables.[20] First, we control for bilateral trade in spirit of Frankel and Rose (1998) and Baxter and Kouparitsas (2005). Its effect

20 Descriptive statistics for all variables are reported in table 3.7 in the appendix.

is ambiguous in theory, as it may depend on whether trade integration is mainly based on intra-industry or rather on inter-industry trade (De Grauwe, 2009). In the empirical academic literature, however, the positive influence of this factor on BC convergence has been well established (Frankel and Rose, 1998). The bilateral trade measure is constructed as follows

$$\text{Bilateral trade}_{ij,t} = \frac{Exports_{ij,t} + Exports_{ji,t}}{GDP_{i,t} + GDP_{j,t}} \tag{3.4}$$

where $Exports_{ij,t}$ refers to all exported goods from country i to country j at time t. The bilateral and time-varying nature of this variable is ideal for our purposes. The determinant reflects the country-pair's trade interconnectedness relative to their GDP. To account for possible endogeneity issues bilateral trade will be instrumented accordingly.

Second, we include a measure reflecting the divergence in national fiscal policies. The variable has been frequently mentioned in the academic literature (Kenen, 1969; Annett, 2006; Lane, 2006; Gächter and Riedl, 2014). Once again, the impact of fiscal policy is ambiguous from a theoretical perspective. While fiscal interventions could possibly be used to counterbalance idiosyncratic economic shocks, proactive fiscal policies are a potential source of asymmetric shocks. Whereas the former would subsequently foster cyclical convergence, the latter may well have the opposite effect. Although ambiguous in theory, the Maastricht Treaty and the Stability and Growth Pact strongly emphasized the restrictions of national leeway with respect to fiscal policies. To properly reflect annual fiscal budget differentials across EU countries we use the measure already employed by Gächter and Riedl (2014) and Gruber (2010), i.e.,

$$\text{Fiscal policy}_{ij,t} = |fb^{ca}_{i,t} - fb^{ca}_{j,t}| \tag{3.5}$$

where $fb^{ca}_{i,t}$ and $fb^{ca}_{j,t}$ represent the cyclically adjusted fiscal balance (net lending/net borrowing in percent of GDP) of country i and j at time t, respectively.[21] So far, empirical papers have found that divergent fiscal policies are negatively related to business cycle co-movement (Darvas et al., 2005; Gruber, 2010; Gächter and Riedl, 2014).

Finally, we attempt to capture the effect of financial integration on BC synchronization. The variable might potentially play a role through two alternative channels. First, higher capital mobility is associated with faster cross-country spillovers and therefore might lead to a higher degree of cyclical correlation. On the other hand, more developed financial markets can provide a significant source of insurance against asymmetric shocks. Countries can thus afford to specialize more strongly (see Kalemli-

[21] Data were extracted from Eurostat for the years from 1990 and 2011 and complemented with data obtained from the Vienna Institute for International Economic Studies.

Ozcan et al., 2005), which in turn should have a negative impact on economic co-movement. Hence, the relationship is unclear in theory. To improve the comparability of our estimates we resort to an indicator developed by Lane and Milesi-Ferretti (2007), who have collected data of external assets and liabilities for individual countries over time. Based on these data, we construct a bilateral measure of financial integration, which is calculated as the sum of two countries' external (foreign) assets and liabilities as a share of the sum of their GDPs. More precisely, the measure is defined as

$$\text{Financial integration}_{ij,t} = \frac{A_{i,t} + L_{i,t} + A_{j,t} + L_{j,t}}{GDP_{i,t} + GDP_{j,t}} \tag{3.6}$$

where $A_{i,t}$ and $L_{i,t}$ represent a country i's total external assets and liabilities in year t. Assets and liabilities include portfolio equity, foreign direct investment, debt and financial derivatives.[22] A high value of this quantity-based measure indicates that both countries' financial markets are likely to be relatively integrated.

3.4 The econometric model

To properly assess the effect of diverging labor cost developments on the synchronization of business cycles we have to address two important issues. First, unit labor costs might react to the business cycle rather than *vice versa*. We will therefore apply GMM methods to control for potential endogeneity. Second, according to a test for autocorrelation the dependent variable is serially correlated. For this reason, we have to consider the first lag of the respective synchronization measure as an explanatory variable. The following dynamic panel data model is employed:

$$\begin{aligned} Correl_{ij,t} =& \alpha + \beta_1 Correl_{ij,t-1} + \beta_2 \text{Labor costs}_{ij,t} + \beta_3 EMU_{ij,t} \\ &+ \beta_4 (\text{Labor costs} \times EMU)_{ij,t} + \beta_5 Z_{ij,t} + \mu_{ij} + \lambda_t + \nu_{ij,t} \end{aligned} \tag{3.7}$$

where ij represents the country pair $ij = 1, ..., 351$ while t denotes the time periods $t = 1, ..., 19$. In order to test the hypothesis that different labor cost developments among country pairs cause business cycles to diverge particularly within a currency union, we include the interaction term $(Labor\ costs \times EMU)_{ij,t}$. The constitutive terms *Labor costs* and *EMU* capture the basic effects of the two variables. The latter takes on values of 1 if both countries i and j are members of EMU in year t and 0 otherwise. The coefficient estimate of the interaction term (β_4) is the key component of our analysis. It will reveal whether the impact of diverging labor cost developments on BC synchronization is significantly more pronounced for countries within EMU than for country pairs with different currencies. Based on our reasoning in previous sections of this paper, we would expect (β_4) to be negative while (β_2) should be insignificant given

22 The database can be downloaded from `http://www.philiplane.org/EWN.html`.

that countries outside the EMU can mitigate changes of competitiveness by steering the value of their currency accordingly. Recent research from Gächter and Riedl (2014) shows that the adoption of the euro has increased the co-movement of business cycles across EMU members. We thus expect a positive coefficient estimate for this factor. The set of control variables is represented by matrix Z and consists of bilateral trade, financial integration and fiscal differentials. Finally, we include time-fixed effects (λ_t) as well as country-pair specifics (μ_{ij}).

The model in (3.7) is estimated by applying the feasible system GMM estimator introduced by Blundell and Bond (1998). This method adequately addresses the endogeneity issues of our data set as it not only uses lags in levels as instruments for the differenced variables as suggested by Arellano and Bond (1991) but also past differences as instruments for variables in levels. This is of particular importance for our study, as we apply time invariant measures such as the distance between country-pairs to instrument bilateral trade. Additionally, the application of the feasible GMM estimator also allows us to control for arbitrary patterns of heteroskedasticity. Although the method assumes that disturbances are not correlated across country pairs, which imposes a restriction on the error terms, this is reasonable given that time-dummies are included in all our regressions (Roodman, 2009).[23]

3.5 Results

3.5.1 Baseline estimations

The baseline results of the empirical investigation are presented in table 3.4. Column (1) includes our main variables of interest only, i.e. the labor cost indicator (differences in NULC growth), a dummy for EMU membership, and the interaction term between the two. Furthermore, we also add a lagged dependent variable given that the Arellano-Bond test confirms that the disturbances are autocorrelated of order one (but not of order two). All estimations in table 3.4 include country-pair specific and time-fixed effects, and the Hansen test of overidentifying restrictions indicates that the used set of instruments is valid across all specifications. Indeed, the results suggest that different growth rates of NULC per se do not have any significant effect on bilateral

[23] For the concrete implementation of the estimator we use the stata command xtabond2 (option: two-step robust). Since the EMU dummy, bilateral trade, labor costs and the interaction term are assumed to be endogenous, we add them in the *gmmstyle* option. All other variables enter in the *ivstyle* option. Furthermore, we add external instruments for bilateral trade as additional exogenous variables. Concretely, we use three gravity variables commonly referred to in the literature: distances between two country pairs in logs, a common border dummy and a country's population size in logs. Due to the large number of instruments resulting from our chosen methodology and the associated specification choices, we restrict the number of instruments applied up to five time lags. This guarantees that the endogenous variables are not overfitted and that the Hansen test statistic is not weakened.

Table 3.4: Estimation results

	No controls (1)	Baseline (2)	Alternative wage measure 1 (3)	Alternative wage measure 2 (4)	BK-filter (5)	Unfiltered GDP-growth (6)	External instrument (7)
Labor costs	-0.002	-0.004	-0.002	-0.002	0.002	0.007	-0.003
	(-1.26)	(-1.22)	(-0.52)	(-0.78)	(0.47)	(1.64)	(-0.70)
EMU member	0.506***	0.300***	0.333***	0.378***	0.650***	0.303***	0.367***
	(7.02)	(3.53)	(3.65)	(4.57)	(6.04)	(3.22)	(3.97)
$Laborcosts \times EMU$	-0.136***	-0.110***	-0.087***	-0.145***	-0.208***	-0.143***	-0.134***
	(-5.03)	(-3.56)	(-2.86)	(-4.53)	(-5.99)	(-4.13)	(-4.13)
Bilateral trade		0.075***	0.074***	0.075***	0.057***	0.048***	0.080***
		(5.14)	(4.98)	(5.19)	(3.67)	(3.58)	(5.07)
Fiscal policy		-0.013**	-0.021***	-0.022***	0.008	-0.004	-0.015**
		(-2.28)	(-3.75)	(-3.80)	(1.06)	(-0.65)	(-2.45)
Financial integration		0.178***	0.051	0.146***	0.083*	0.105***	0.193***
		(4.45)	(1.27)	(3.52)	(1.83)	(2.66)	(4.60)
$Correl_{t-1}$	0.168***	0.068***	0.082***	0.065***	0.035*	0.152***	0.061***
	(4.96)	(4.31)	(4.79)	(4.12)	(1.89)	(5.08)	(3.81)
Obs	6247	5750	5021	5584	4655	5752	5349
Hansen	336.817	340.939	346.198	347.610	343.716	343.752	345.44
Hansen p	0.109	0.822	0.978	0.748	0.793	0.710	0.468
AR(1) p	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR(2) p	0.990	0.194	0.116	0.285	0.867	0.088	0.106

Two-tailed significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. T-statistics are reported in parenthesis. Out-of-sample instruments included: logdistance, logpopulation, common-border dummy. In-sample instruments: up to 5 lags. All estimations include country-specific and time-fixed effects as well as a lagged dependent variable given that the Arellano-Bond test confirms that the disturbances are autocorrelated of order one (but not of order two). Explanatory variables in column (8) are one-period lagged. Column (1) includes our main variables of interest only, i.e. the labor cost indicator (differences in NULC growth), a dummy for EMU membership, and the interaction term between the two. Column (2) adds three additional controls: bilateral trade, fiscal policy, and financial integration. Columns (3) and (4) use exchange rate adjusted ULCs from the OECD and absolute bilateral differences of labor compensation per employee, respectively. Column (5) reports results when a Baxter-King band-pass filter is employed instead of the Hodrick-Prescott technique used in all other specifications. Column (6) uses simple (unfiltered) GDP growth rates instead of cyclical components to calculate the correlation measure. Column (7) employs an additional instrument variable: an index that measures the type of coordination of wage setting on a scala from 1 (uncoordinated bargaining) to 5 (centralized bargaining by peak associates with or without government involvement).

cyclical correlations. Interestingly, however, the negative coefficient of the interaction term of the two variables, *Labor costs* $\times$ *EMU* is highly statistically significant. Thus, while differences in NULC growth across countries seem to have no explanatory power for BC synchronization of countries outside a common currency area, this factor gains importance within such a union, where the common currency (i.e. the fixed nominal exchange rate) does not allow for any (short-term) adjustment of the real exchange rate. This first estimation thus supports our hypothesis that differences in wage developments lead to significantly less synchronized business cycles in a currency union. At the same time, the same channel does not seem to matter for countries outside the currency union, where differences in wage developments can be counter-balanced by movements of the (nominal) exchange rate. The regression also confirms the positive impact of EMU membership *per se* on cyclical synchronization, which has been suggested by Gächter and Riedl (2014).[24]

Column (2) adds three additional controls. The importance of bilateral trade for business cycle co-movements has been firmly established in the academic literature since the seminal contribution by Frankel and Rose (1998) and is also confirmed by our estimation. Hence, more intense bilateral trade relations between two countries lead to higher co-movement of their business cycles. The same holds true for financial integration. Differences in fiscal policy – defined as the absolute difference of (cyclically adjusted) budget balances in percentage points of GDP – on the other hand, significantly reduce the co-movement of business cycles. Thus, idiosyncratic (national) fiscal shocks exercise a stronger (negative) effect on cyclical synchronization than the potentially stabilizing (positive) effect of countercyclical fiscal policy which is in line with the results in Darvas et al. (2005), Gruber (2010), and Gächter and Riedl (2014). Importantly, however, the inclusion of these control variables does not interfere with the outcomes regarding our main hypothesis, i.e. the coefficients for *Labor costs* and *Labor costs* $\times$ *EMU*.[25] In fact, the strongly negative effect of diverging unit labor costs within the currency area prevails across all specifications.

Even more remarkable, however, is the economic significance of unit labor cost divergence for business cycle synchronization within a currency union. When the baseline regression in column (2) is repeated by calculating standardized coefficients, the interaction term between unit labor costs and the EMU dummy shows a slightly higher beta coefficient (-0.104) than the bilateral trade variable (0.100). Thus, when considering the standard deviations of the corresponding variables, the magnitude of the impact of differences in nominal unit labor costs is roughly equal to the impact of bilateral trade relations, which have been repeatedly highlighted as one of the most impor-

[24] The authors conclude that this positive 'euro effect' is likely due to stronger spillovers across countries, increased labor mobility and the establishment of common risk sharing systems within EMU.

[25] Note, however, that the consideration of bilateral trade reduces the magnitude of the *EMU* coefficient, which is due to their considerable correlation.

tant determinants of business cycle synchronization. Thus, our results highlight the enormous importance of unit labor cost developments for business cycle convergence across countries within a currency union. On the contrary, while the coefficient for unit labor costs is generally negative, the effect is not statistically significant for countries outside EMU.

Regressions (3) and (4) subsequently use alternative measures for the *Labor costs* variable. Column (3), for instance, reports the results concerning the growth rate of exchange rate adjusted ULCs, which are obtained from the OECD database.[26] The variable converts total labor costs to a USD basis and divides this number by a real output series, reported in USD as well.[27] Model (4) applies a further definition of the labor cost indicator and uses growth differences of labor compensation per employee, i.e. the numerator of the NULC indicator. This robustness test is of particular importance for this study. After all, it could be argued that the negative link between business cycle synchronization and NULC growth differences exists by definition given that NULCs are defined as the quotient of total labor costs and real output. Hence, when business cycles diverge, and real GDP growth rates drift apart, the corresponding NULC growth differential may rise mechanically. Although the system GMM estimator is theoretically able to cope with this form of endogeneity, it is nevertheless useful to show that our results are not driven by this technical feature of the NULC indicator. We find that the outcomes are indeed robust to this specification. Once again, these insights document that the divergence of labor costs does not affect cyclical synchronization outside EMU, but has a strong (negative) effect on BC co-movement within EMU. The coefficients of the remaining control variables are not affected by this adjustment. Model (5) subsequently employs a Baxter-King band-pass filter (Baxter and King, 1999) instead of the Hodrick-Prescott technique used in all other specifications (Hodrick and Prescott, 1997). Due to the technical properties of the former we lose three years at the end of our sample. The higher coefficient of the interaction term may be the consequence of this constraint and suggests that the role of unit labor costs may have been particularly pronounced prior to the crisis when they were not subject to sudden idiosyncratic political interventions and covenants attached to international rescue packages. Model (6) uses simple (unfiltered) GDP growth rates instead of the cyclical components to calculate the correlation measure. The dependent variable thus coincides with the one proposed by Cerqueira and Martins (2009). In both cases, the empirical results are qualitatively unaffected; the strong impact of wage

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26 The exact definition can be found at `http://stats.oecd.org/mei/default.asp?lang=e&subject=19`. The OECD explicitly recommends this variable to compare ULC developments across countries in a common currency. While short-term movements can be very volatile as they are largely dependent on developments in the exchange rate, the time-fixed effects in our estimation are able to account for this effect. Thus, if the nominal exchange rate adjusted according to corresponding developments in NULC growth, this variable would not show any difference between the two countries, as the (real) exchange rate between the two countries remained constant.

27 Note that the conversion uses the prevailing exchange rates in the OECD base year.

growth differential on business cycle correlations is confirmed.

Model (7) eventually alters the baseline specification of model (2) by employing an additional instrumental variable to specifically take into account the potential endogeneity issue. As discussed, the causal direction is not entirely clear from an economic perspective. While differences in ULC growth are likely to lead to divergence in two countries' business cycles (see section 3.2), a reverse causal effect also seems possible. More precisely, business cycle divergences between two countries are likely to eventually lead to differences in wage growth (amplified by differing inflation rates), and thus, in ULC growth. While our dynamic panel method is theoretically able to consider this type of endogeneity by employing internal instruments (i.e. lags of the corresponding variables), we nevertheless employ a robustness check by adding an external instrument. For that purpose, we need an instrumental variable which is highly correlated to the differences in ULC growth, while it is not (directly) related to business cycle synchronization. Because national wage developments are not only determined by (national) business cycles, but also by national wage bargaining systems, we use a corresponding variable from the ICTWSS database to instrument ULC growth differentials.[28] The index variable *coord* measures the type of coordination of wage setting on a scala from 1 (uncoordinated bargaining) to 5 (centralized bargaining by peak associations with or without government involvement). There is a broad literature on the empirical fact that the level of wage restraint is considerably influenced by the level of centralization of the wage bargaining process (see, for instance, Aidt and Tzannatos, 2008). Furthermore, a simple panel estimation linking the difference in ULC growth to the difference in the index variable *coord* shows a positive link between the two variables which is highly significant. Thus, the *coord* seems to be an appropriate instrumental variable for our purposes. The empirical results are shown in model (7). Interestingly, while the results are qualitatively unaffected by this additional external instrument, the magnitude of the effect of differences in ULC growth on business cycle synchronization within a currency union even increases in this specification. Thus, we conclude that the causal direction indeed moves from wage growth differences to business cycle divergence rather than the other way round.

3.5.2 Further robustness checks

Table 3.5 presents further robustness tests. In a first step, column (1) excludes the financial crisis and restricts the sample to the years 1993 to 2007. While the results remain qualitatively unchanged, the larger coefficient on the interaction term confirms the findings of the Baxter-King specification from above. The negative effect of

[28] Database on Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts in 34 countries between 1960 and 2012. For further information, see `http://www.uva-aias.net/208`.

TABLE 3.5: Robustness checks

	excluding crises	after 1999	winsorized	RE-model	EMU only
	(1)	(2)	(3)	(4)	(5)
Labor costs	-0.003	-0.003	-0.004	-0.004*	
	(-0.86)	(-0.79)	(-0.95)	(-1.74)	
EMU member	0.640***	0.298***	0.307***	0.212***	
	(6.61)	(3.56)	(3.48)	(3.36)	
$Laborcosts \times EMU$	-0.230***	-0.101***	-0.116***	-0.052***	-0.079***
	(-7.21)	(-3.34)	(-3.75)	(-2.63)	(-3.27)
Bilateral trade	0.058***	0.076***	0.074***	0.064***	0.167***
	(3.67)	(5.11)	(5.16)	(5.94)	(4.67)
Fiscal policy	-0.005	-0.015**	-0.013**	-0.042***	-0.021**
	(-0.67)	(-2.49)	(-2.27)	(-8.20)	(-2.40)
Financial integration	0.073*	0.099***	0.176***	0.056***	0.261***
	(1.83)	(2.66)	(4.33)	(2.66)	(3.55)
$Correl_{t-1}$	0.088***	0.065***	0.069***		0.056
	(5.27)	(3.96)	(4.46)		(1.55)
Obs	4348	4532	5750	5446	1064
Hansen	340.8136	344.5009	343.8256		126.31
Hansen p	0.4621	0.9596	0.7916		0.9560
AR(1) p	0.0000	0.0000	0.0000		0.000
AR(2) p	0.1082	0.1188	0.2144		0.221

Two-tailed significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. T-statistics are reported in parenthesis. Out-of-sample instruments included: logdistance, logpopulation, common-border dummy. In-sample instruments: up to 5 lags. All estimations include country-specific and time-fixed effects as well as a lagged dependent variable given that the Arellano-Bond test confirms that the disturbances are autocorrelated of order one (but not of order two). Column (1) excludes the financial crisis and restricts the sample to the years 1993 to 2007. Column (2) drops the years before the introduction of the euro. Column (3) winsorizes the *Labor costs* variable at the 95 percentile. Column (4) estimates a simple random effects panel model without the dynamic component. Column (5) restricts the sample to EMU country-pairs only.

diverging ULC developments seems to have been more intense before the onset of the crisis. The specification in column (2) drops the years before the introduction of the euro. Since some country pairs exhibit extreme absolute NULC differences for certain years, the *Labor costs* variable is winsorized at the 95 percentile in regression (3). The estimation is thus more robust to outliers while – as opposed to trimming – the loss of data is limited to a minimum. A simple random effects panel model without the dynamic component (i.e. excluding the lagged dependent variable) is applied in model (4).[29] While this model is clearly inferior from a technical perspective as compared to its dynamic GMM counterpart, it constitutes a meaningful robustness check for our analysis. Even this simple static estimation confirms that diverging wage development within the EMU must not be disregarded by policymakers when discussing further measures to bring the euro area closer to an OCA. Specification (5) restricts the sample to EMU country-pairs only, which means that the sample starts only in 1999 or later for some pairs. Finally, in order to ensure that the results are not driven by a single country, we re-estimate the baseline model repeatedly and exclude one country at a time. Thus, 26 (out of 351) country pairs are consequently dropped from the sample in each regression. The outcomes reported in table 3.6 are unambiguous. The sign and the significance of our main variables remain unchanged across all specifications.

Overall, the results uniformly support our main hypothesis and are insensitive to a number of robustness checks and alternative estimation techniques. Diverging dynamics in NULC substantially reduce bilateral business cycle synchronization within EMU, while the impact is limited or even non-existent for countries outside the monetary union. Put differently, while EMU membership *per se* increases business cycle synchronization, the effect is counteracted by distortions on national labor markets. The empirical results therefore suggest that wage negotiations should be more closely coordinated across EMU member states and that nominal thresholds alone – as included in the MIP – may be insufficient.

3.6 Discussion and conclusion

The recent crisis has highlighted some crucial deficits of the euro area's political and institutional framework. National policy decisions and fiscal fragmentation partly stand in conflict with financial integration and the ECB's common interest rate policy. The latter is most efficient for a homogeneous group of countries. During the run-up of the crisis, however, excessively generous wage increases above productivity trends in Europe's periphery have triggered the build-up of substantial imbalances. This

[29] In order to (partly) account for endogeneity issues, all explanatory variables were used in their one-period lagged form. The estimation uses the Stata routine *xtivreg*. We instrument bilateral trade with the commonly applied gravity variables: distance (in logs), population, and common border.

Table 3.6: Robustness to country-exclusion

Country	Labor costs	Labor costs × EMU	Country	Labor costs	Labor costs × EMU
AUT	-0.005	-0.106***	IRE	-0.004	-0.128***
	(0.004)	(0.034)		(0.004)	(0.035)
BEL	-0.007**	-0.101***	ITA	-0.005	-0.097***
	(0.004)	(0.033)		(0.004)	(0.034)
BUL	-0.007*	-0.116***	LTU	-0.009**	-0.112***
	(0.004)	(0.031)		(0.004)	(0.031)
CYP	-0.005	-0.125***	LAT	-0.009**	-0.110***
	(0.004)	(0.032)		(0.004)	(0.032)
CZE	-0.005	-0.108***	LUX	-0.006	-0.108***
	(0.004)	(0.031)		(0.004)	(0.031)
GER	-0.004	-0.084**	MLT	-0.006	-0.100***
	(0.004)	(0.034)		(0.004)	(0.033)
DEN	-0.004	-0.111***	NED	-0.004	-0.096***
	(0.004)	(0.033)		(0.004)	(0.032)
EST	-0.007*	-0.115***	POL	-0.001	-0.112***
	(0.004)	(0.031)		(0.004)	(0.032)
ESP	-0.005	-0.117***	POR	-0.005	-0.123***
	(0.004)	(0.033)		(0.004)	(0.030)
FIN	-0.003	-0.097***	ROM	-0.004	-0.103***
	(0.004)	(0.033)		(0.005)	(0.032)
FRA	-0.004	-0.105***	SWE	-0.004	-0.105***
	(0.004)	(0.035)		(0.004)	(0.031)
GBR	-0.003	-0.105***	SVK	-0.005	-0.120***
	(0.004)	(0.032)		(0.004)	(0.031)
GRE	-0.005	-0.089**	SLO	-0.004	-0.122***
	(0.004)	(0.040)		(0.004)	(0.030)
HUN	-0.002	-0.118***			
	(0.004)	(0.032)			

Two-tailed significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. T-statistics are reported in parenthesis. The regression is based on the baseline specification (column (2) of Table 3.4). The baseline model is re-estimated repeatedly excluding one country at a time; The two coefficients for 'Austria', for example, show the impact of labor cost developments on business cycle co-movement when Austrian data is excluded.

empirical study shows that distinct wage-setting behavior across EMU countries has significantly contributed to divergent business cycle co-movement since 1999. In fact, bilateral differences of nominal unit labor cost developments turn out to be among the most important determinants for cyclical synchronization within a currency union. Interestingly, NULC movements are irrelevant for the period before the introduction of the euro and for countries outside the euro area, where losses of competitiveness can be mitigated by a depreciation of the nominal exchange rate.

These novel findings fill an important gap in the literature, and thereby add a crucial building block to both the empirical OCA literature of the 1990s and 2000s and the original theories of the 1960s and 1970s. The insights are economically substantial and highly statistically significant. We also control for bilateral trade ties, financial integration, and national fiscal policies, which have been found to matter in numerous studies in the past, and confirm their relevancy. Our results draw on modern econometric techniques and withstand various robustness checks regarding time spans, business cycle measures and filtering methods. Furthermore, our study clarifies an important ambiguity of the theoretical literature, in which two contesting strands stress both the equilibrating and the dis-equilibrating role of heterogeneous wage developments on business cycle co-movement.

Given the intense debates on competitiveness within EMU and the considerable implications for the single monetary policy it is surprising that the role of nominal labor cost developments has not been investigated before in this context. The insights of this paper suggest that the original EMU treaties, which place particularly strong emphasize on fiscal variables, must be extended by a focus on national wage developments. While the newly created MIP in the framework of the Alert Mechanism Report (AMR) by the European Commission points in the right direction, our results imply that the focus on nominal thresholds alone is clearly insufficient. A reformed monitoring system should predominantly aim at avoiding disproportional relative wage adjustments across EMU countries. A lack of coordination, on the contrary, may facilitate the emergence of economic and financial imbalances, destabilize the euro area and increase the cost of the common currency.

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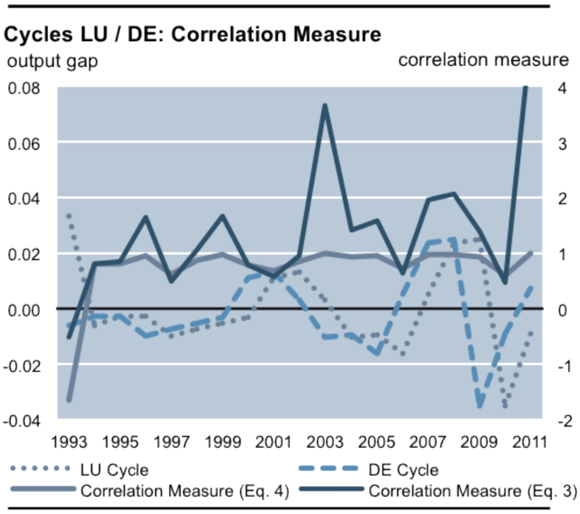
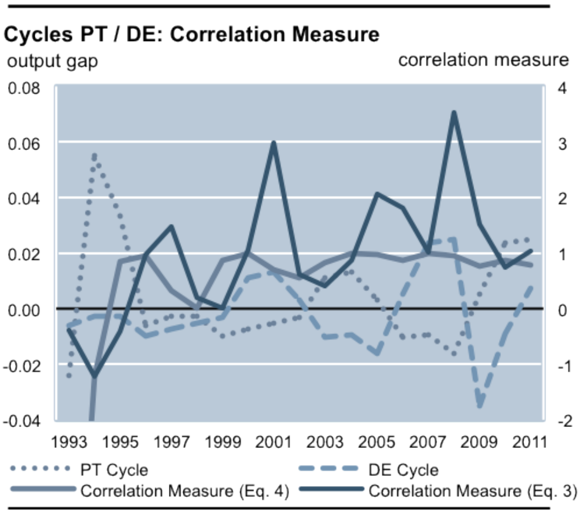
Appendix

3.A Business cycles

(A)



(B)



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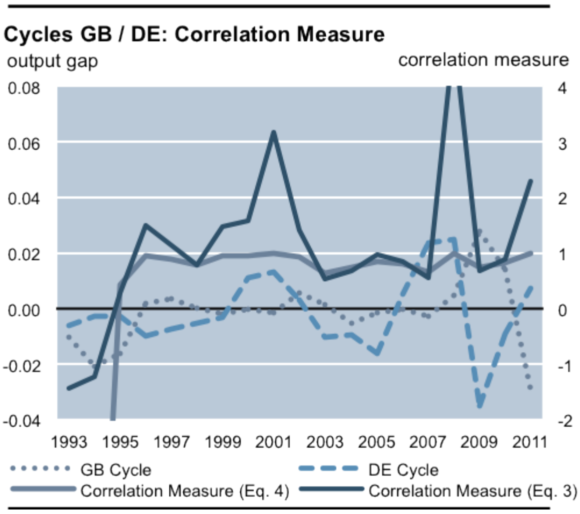
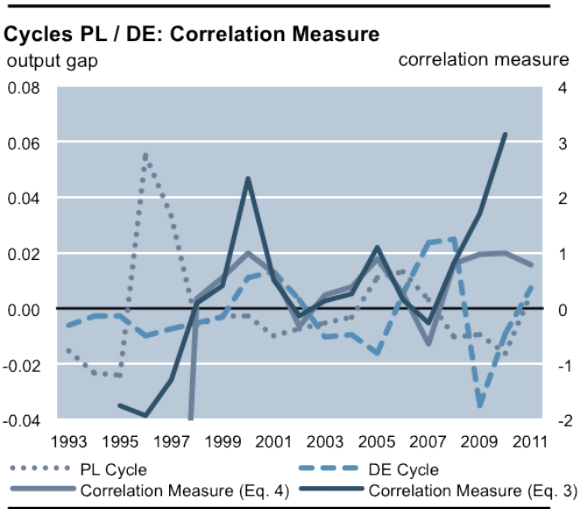


(D)



Avg. BC correlation with Germany (1994-2011, shaded cells indicate EMU membership in '11)

AT	BE	BG	CY	CZ	DK	EE	ES	FI	FR	GB	GR	HU
0.93	0.89	0.52	0.61	0.61	0.84	0.75	0.91	0.89	0.92	0.85	0.33	0.74
IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SL	SK
0.73	0.93	0.56	0.85	0.75	0.69	0.89	0.51	0.68	0.34	0.83	0.82	0.62

The panels show selected individual business cycles as well as pair-wise correlation measures as introduced in equations (3.1) and (3.2). Germany serves as the general reference point across all graphs and tables. Average correlation measures with Germany for the period between 1993 and 2011 – as measured by the bounded index (eq. 3.2) – are stated at the bottom. The latter has been highest with other core countries of the EMU such as Germany/Luxembourg (0.85) or Germany/Austria (0.93), while Germany's business cycle shows less co-movement with peripheral economies. Still, the average historical correlation coefficient for Germany/Portugal (0.68) and Germany/Ireland (0.73), for example, is far above those for EMU/non-EMU country pairs such as Germany/Poland (0.51) or Germany/Bulgaria (0.51). The EU pairs Germany/Great Britain (0.85) and Germany/Sweden (0.83) are notable but plausible exceptions. After all, these countries share strong international trade ties as well as similar economic levels of development.

FIGURE 3.8: Cycles and correlation measures

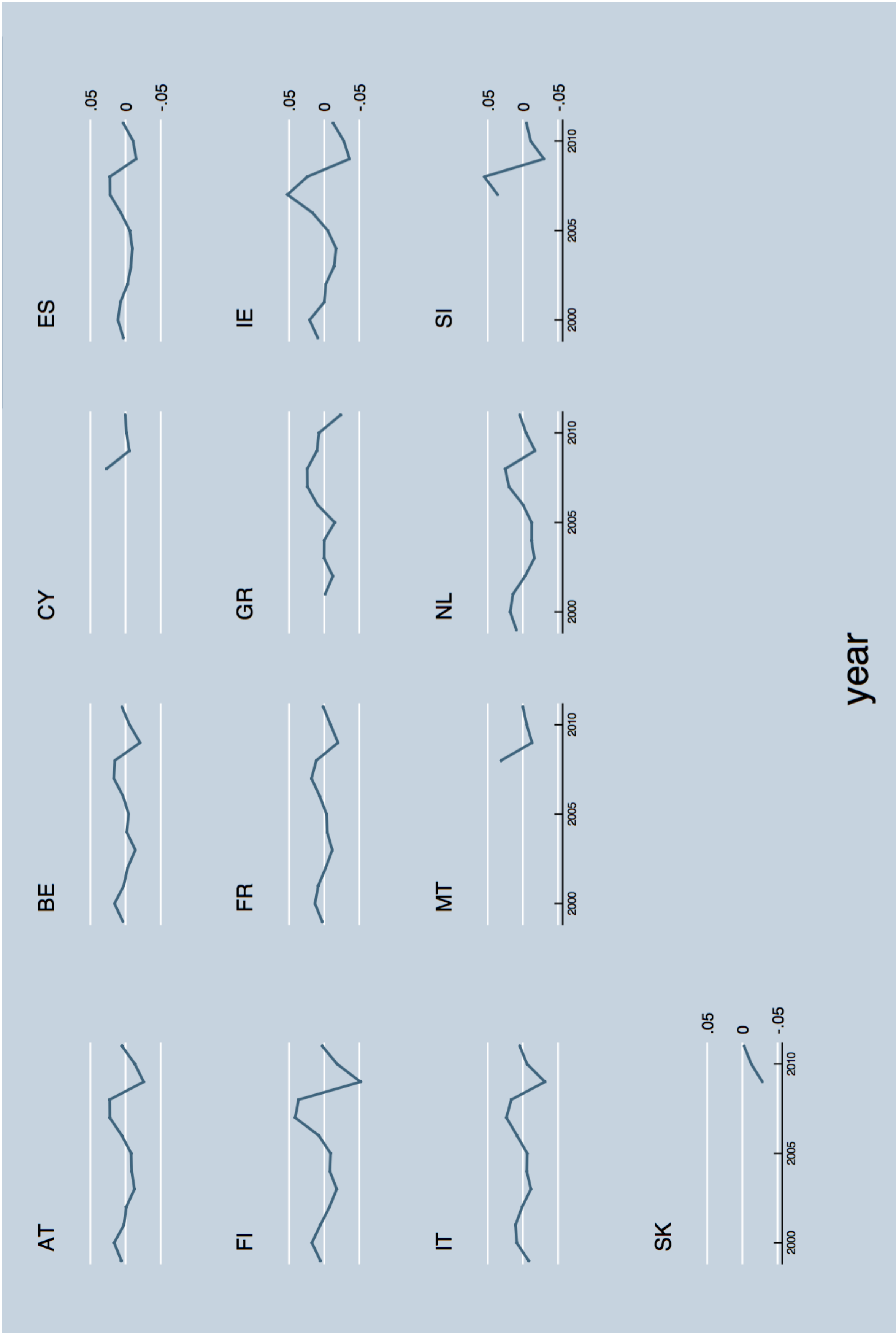


FIGURE 3.9: Business cycles of European countries over time

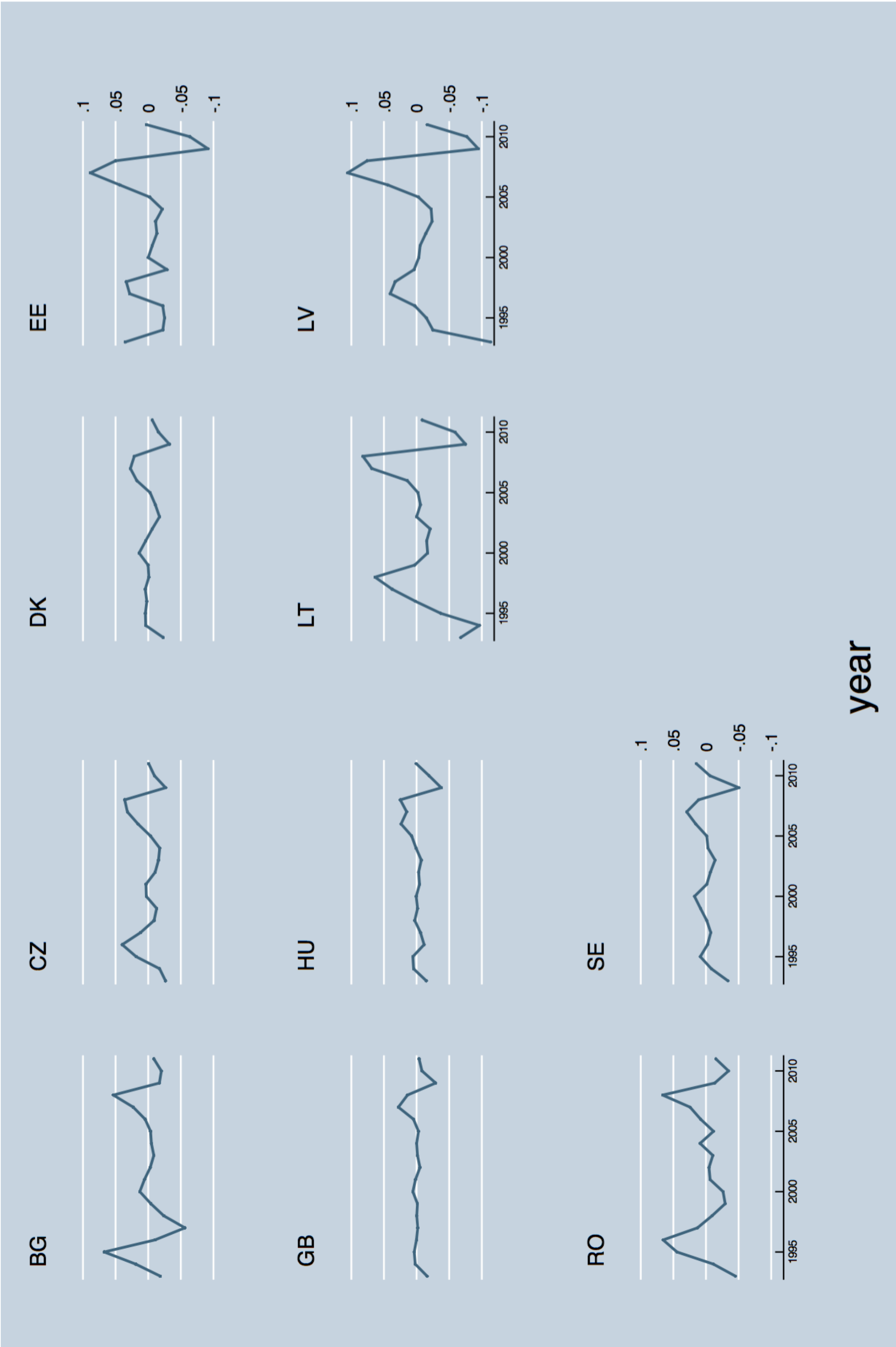


FIGURE 3.10: Business cycles of European countries over time cont'd

3.B Descriptives

FIGURE 3.11: Histogram of nominal unit labor costs

Table 3.7: Descriptive statistics

Variable		Mean	Std. Dev.	Min	Max	Observations
NULC Growth*	overall	2.816	5.390	-23.067	15.090	N = 6367
	between		1.911	.577	6.597	n = 351
	within		5.046	-24.992	16.980	$\bar{T}$ = 18.140
NULC Growth Differential*	overall	6.186	6.482	.002	24.896	N = 6228
	between		3.111	.882	15.521	n = 351
	within		5.669	-8.916	28.225	$\bar{T}$ = 17.744
NULC Level Differential	overall	15.103	16.614	0	103.912	N = 6408
	between		8.669	1.121	37.329	n = 351
	within		14.182	-22.226	86.218	$\bar{T}$ = 18.256
$Correl^{HP}$	overall	1.260	1.146	-1.130	7.985	N = 6668
	between		0.335	0.344	2.338	n = 351
	within		1.097	-1.522	7.255	$\bar{T}$ = 18.997
$Correl^{BK}$	overall	1.292	1.168	-0.962	8.332	N = 5417
	between		0.340	0.475	2.442	n = 351
	within		1.118	-1.269	7.904	$\bar{T}$ = 15.433
$Spread^{HP}$	overall	1.541	1.745	0.000	14.867	N = 6669
	between		0.906	0.288	3.973	n = 351
	within		1.492	-2.351	14.672	T = 19
EMU	overall	0.160	0.366	0.000	1.000	N = 6669
	between		0.256	0.000	0.684	n = 351
	within		0.262	-0.525	1.107	T = 19
ERM	overall	0.322	0.467	0.000	1.000	N = 6669
	between		0.357	0.000	1.000	n = 351
	within		0.302	-0.468	1.006	T = 19
Bilateral Trade[1,**]	overall	-6.562	1.657	-12.612	-2.199	N = 6350
	between		1.586	-10.120	-2.498	n = 351
	within		0.488	-10.247	-3.257	$\bar{T}$ = 18.091
Bilateral Trade[2,***]	overall	-6.127	1.669	-12.698	-1.995	N = 6350
	between		1.628	-10.116	-2.707	n = 351
	within		0.414	-9.821	-2.977	$\bar{T}$ = 18.091
Fiscal Policy	overall	3.693	3.149	0.002	32.067	N = 6019
	between		1.577	1.043	9.459	n = 351
	within		2.723	-3.659	30.890	$\bar{T}$ = 17.148
EU	overall	0.560	0.496	0.000	1.000	N = 6669
	between		0.269	0.263	1.000	n = 351
	within		0.417	-0.335	1.296	T = 19
Financial Integration[2]	overall	1.610	2.127	0.000	16.910	N = 4713
	between		1.113	0.101	4.426	n = 351
	within		1.810	-2.750	14.196	$\bar{T}$ = 13.427
Distance, in logs	overall	7.093	0.649	4.007	8.236	N = 6669
	between		0.650	4.007	8.236	n = 351
	within		0.000	7.093	7.093	T = 19
Common border	overall	0.194	0.503	0.000	2.000	N = 6669
	between		0.504	0.000	2.000	n = 351
	within		0.000	0.194	0.194	T = 19

* winsorized right-sided, 5 % of observations modified; ** measured in % of GDP, in logs; *** measured in % of total trade, in logs.

Chapter 4

Banks and Sovereigns: A Model of Mutual Contagion

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3 The paper has been presented at the Spring Meeting of European Young Economists 2013, the Brown Bag Seminar of the Swiss Institute of Banking and Finance, the PhD seminar at the University of St. Gallen, the Campus for Finance conference at the WHU Otto Beisheim School of Management, and the Seminar to the Summer School of the Barcelona GSE.
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Abstract

We develop a model of the bank-sovereign nexus to study the interplay of bank and sovereign risks as well as the implications of deposit insurance for risk and welfare. It uniquely combines financial instability due to banks' asset risk with sovereign debt fragility in the form of multiple equilibria and self-fulfilling debt crises. We show how a bad realization of the stochastic loan return directly affects the bank and how it may also cause a sovereign default due to deposit insurance cost or an erosion of the tax base. Interestingly, the provision of deposit insurance can either trigger or prevent a sovereign default. The latter possibility tends to be more likely whenever the insurance scheme prevents high cost of a disorderly bank liquidation. Deposit insurance raises domestic consumption and welfare by avoiding liquidation cost and by effectively shifting the public debt burden onto foreign bondholders. Unlike in other models, however, the sovereign default is not a strategic decision but rather a consequence of weak fundamentals and deposit protection commitments. The preferential regulatory treatment of sovereign risks induces banks to invest in government bonds such that they additionally become sensitive to the country's fiscal state and possible adverse feedbacks. Banks may therefore fail because of a sovereign default in situations in which they would survive otherwise. Surprisingly, we also find that relatively low levels of fiscal fragility may actually improve financial stability since higher bond returns provide a buffer which improves banks' robustness to poor loan performance. When a certain level of fragility is exceeded, however, this relation is reversed. Stricter capital requirements naturally reduce sovereign and bank risk in our setting, although the model hints at possible countervailing effects as well.

JEL classification: G11, G21, G28, H63

Keywords: *Bank-Sovereign Nexus, Contagion, Sovereign Debt Crisis, Financial Stability, Capital Regulation*

'We are working very hard to try to sever this bank-sovereign link, but the more we examine it, the more it seems that it's never-ending' (Sharon Bowles, chairwoman of the European Parliament's Economic and Monetary Affairs Committee, Bloomberg (2014))

'One of the biggest lessons of the current crisis is that there is no risk-free asset, so sovereigns are not risk-free assets. That has been demonstrated, so now we have to react' (Danièle Nouy, the euro zone's new chief banking regulator, Financial Times (2014))

'The eurozone is one of the most dangerous places. I'm a bit anxious about the situation there... The European banking system is in bad shape and it's not easy to change things there, because there is an unhealthy symbiosis between governments and banks, which need each other and everyone is connected through the currency. This is economically unstable and unhealthy.' (Anat Admati, Globes (2014))

4.1 Introduction

The recent financial crisis has emphatically demonstrated that bank and sovereign risks are inherently and inevitably intertwined. A crisis of the banking industry may trigger disastrous consequences for the economy as a whole and induce the governments to intervene. In fact, rescue packages for distressed banks or other systemically important financial institutions took center stage in many countries in the recent past. Given that the size of the banking sector often corresponds to a multiple of GDP, the sovereign exposure to such financial risks was exorbitant in many cases. This is especially true for the euro area where the fiscal responsibility for such interventions still lies within national borders although banks have long expanded beyond. As a result, public debt levels successively increased: According to Laeven and Valencia (2012), the public debt-to-GDP ratio increased by almost 20 percentage points in the euro area between 2008 and 2011; this increase was particularly sharp in Ireland (72pp), Greece (45pp), and Spain (31pp). The economic viability of the GIIPS – Greece, Ireland, Italy, Portugal and Spain – and their ability to repay their outstanding debt was suddenly at stake. The abrupt awareness of countries' vulnerability and possible sovereign defaults drove apart the bond spreads in the euro area. Banks, however, had built up a large sovereign exposure as documented by numbers from the 2014 EBA stress test: Belgian banks, for example, held euro area sovereign bonds worth 16 percent of total assets. Italian (14 percent) and German/Maltese/Portuguese/Spanish banks (between 10 and 13 percent) showed a similar exposure (ESRB, 2015). The preferential treatment of sovereign bonds in the Basel accords was certainly conducive to this trend. Especially in the GIIPS countries, bond holdings are likely characterized by a significant home bias: Domestic bonds represented 85 percent of banks' (euro area) sovereign exposure in Italy, and 87 percent in Ireland, 93 percent in Spain and Portugal, and 98 percent in Greece (ESRB, 2015). As the creditworthiness of certain governments decreased, banks were forced to reappraise some of these positions and – as for Greece's debt haircut – to take real losses. A vicious spiral emerged – with negative spillovers from banks to sovereigns and *vice versa*. An even more disastrous credit crunch and further contagion between euro area member states could so far only be averted by massive policy interventions and bailouts.

On closer inspection, the crisis thus revived our awareness for the inherent fragility of banks, which fund themselves with unparalleledly low levels of equity, and their unique interconnectedness with other banks, sovereigns, and market participants. These characteristics set banks apart from ordinary companies and provide the basis for their systemic relevance. Although influential strands of literature consider this fragility a necessary disciplining device, it proved to be a source of financial instability associated with severe negative economic consequences such as bank runs and contagion. A more critical assessment of these characteristics has thus been advocated by Pfleiderer (2014), Admati and Pfleiderer (2010) and Admati and Hellwig (2013), who question the upside of this 'self-imposed' fragility and draw attention to the negative consequences for bank governance, financial stability and welfare overall.

This paper contributes to the emerging literature on the bank-sovereign nexus in several ways: First of all, it develops a comprehensive theoretical framework that highlights the interplay of bank and sovereign risks by combining a fully-fledged model of banks, which are invested in risky assets, with a classical version of sovereign debt fragility. Multiple equilibria may arise. This allows us to capture the key mechanisms of contagion between banks and sovereigns, namely, government guarantees, taxation, and sovereign bond holdings. Importantly, the focus on risks which emerge from the bank's asset side captures a stylized fact of the recent crisis. After all, the latter originated in the sub-prime mortgage market. Existing literature on the bank-sovereign nexus has primarily dealt with contagion issues coming from the public sector. Furthermore, the paper explores the consequences of government guarantees for depositors on sovereign risk and domestic welfare, which sets it apart from other contributions that focus on the implications of *ex ante* bailouts à la Acharya et al. (2014). These welfare and risk effects crucially depend on the (prevented) cost of a disorderly bank liquidation and on the possibility to shift bailout cost onto foreign bondholders. Astonishingly, we find that the provision of deposit insurance can either trigger or prevent a sovereign default. Finally, we investigate the implications of tighter capital requirements for bank and sovereign risks in a setting in which government bonds receive preferential treatment in the sense that they do not need to be backed by equity (as in Basel III): This regulatory framework provides strong incentives for banks to invest in such assets, which makes them sensitive to the fiscal state. Most importantly, it creates the possibility for adverse feedback loops in which banks may fail or be weakened because the government defaults. Interestingly, relatively low levels of fiscal fragility may actually improve financial stability since higher bond returns provide a buffer which improves banks' robustness to poor loan performance. This relationship reverses, however, when a certain level of fiscal fragility is exceeded. Stricter capital requirements are likely to enhance the resilience of sovereigns and banks in our set-up, although the model also raises potential countervailing effects.

The remainder of this paper is organized as follows: Section 4.2 first reviews the related literature. Section 4.3 then introduces the model set-up. Subsequently, section 4.4 characterizes potential equilibria and examines the consequences of providing government guarantees on sovereign risk and domestic welfare. Section 4.5 discusses a variant with capital regulation and section 4.6 eventually concludes.

4.2 Literature

This paper particularly relates to the literature on financial and sovereign debt fragility as well as to recent contributions on the interaction of bank and sovereign risks:

Financial fragility is often modeled by a combination of risky bank assets and small equity. A tractable approach that exemplifies this key feature is a stochastic loan return as in Dermine (1986) and Boyd et al. (2009): Bad realizations of borrowers' returns translate into loan losses, which, if large enough, may wipe out a bank's equity. On the liquidity side, Diamond and Dybvig (1983) investigate the role of excess maturity transformation for banks' inherent susceptibility to runs. They show that a 'good' equilibrium with optimal risk sharing between depositors with different liquidity needs may give way to a 'bad' one, in which all depositors panic and withdraw their deposits.[1] Bank risks, however, must not be examined in isolation. Instead, they are intimately linked through at least two mechanisms: interbank lending and fire sales. Following Diamond and Dybvig (1983), Allen and Gale (2000) develop a network model of interbank lending. Although the latter is beneficial *per se* and allows for optimal risk sharing in order to withstand independent liquidity shocks, it may lead to contagion in case of correlated shocks. Depending on the network structure and the liquidation value of the bank's assets, the crisis of a single institution may then spread over to other banks and become systemic. Likewise, Shleifer and Vishny (1992, 2011) identify the contagious effect of fire sales: They argue that banks which face substantial liquidity withdrawals might be forced to quickly liquidate parts of their assets at a dislocated price. That, in turn, may cause a further deterioration of other banks' balance sheets, which subsequently forces them to sell their assets as well; either because they violate regulatory standards or because depositors start to withdraw. Furthermore, Diamond and Rajan (2011) relate fire sales to the freeze of credit markets. They show that the prospect of future fire sales alone suffices to depress the current asset prices and to cause a 'seller's strike' *ex ante*. Eventually, Greenwood et al. (2015) develop a model of contagion through fire sales and focus on each bank's exposure to system-wide deleveraging and on its own contribution to overall fragility.

Sovereign debt fragility on the other hand arises because a government's ability or willingness to repay its debt may depend on the interest rate, which, in turn, hinges on investors' expectations about future debt repayment. This gives rise to multiple equilibria and self-fulfilling debt crises: If investors are pessimistic about debt repayment, they require a high interest rate, which increases the debt burden and weakens fiscal stability thus justifying their pessimism. In a seminal contribution, Calvo (1988) shows that such a mechanism can be generated by the possibility of debt repudiation, which may lead to multiple equilibria. In our paper, we subsequently rely on a textbook version of this model by Romer (2001), who essentially replaces debt repudiation by a stochastic tax revenue. Detragiache (1996) shows that some of these equilibria materialize as a liquidity crisis while Cole and Kehoe (2000) focus on a so-called crisis zone where sovereign risk depends on market participants' expectations and study

[1] Another branch of the literature, for example, Diamond and Rajan (2000, 2005) emphasizes the importance of financial fragility as a commitment device in the presence of a hold-up problem.

its fundamental determinants as well as optimal debt policy. The empirical relevance of multiple equilibria in the context of sovereign debt is documented, for example, in Reinhart and Rogoff (2011) or De Grauwe and Ji (2013).

Recent events have raised the need for a more integrated view on *financial* and *sovereign debt fragility* thereby laying the ground for topical research on the *bank-sovereign nexus*, to which this paper contributes. On the theoretical side, Bolton and Jeanne (2011), for example, stress the role of sovereign bonds as a collateral in interbank lending. Sovereign risk compromises this function and hampers a bank's investment capacity. A sovereign default may even further limit the banks' capacity of originating investment to its own initial wealth. An extension to a two-country model shows that banks tend to diversify their bond holdings and that this diversification, although beneficial *ex ante*, may trigger financial contagion *ex post*. In a similar spirit, Gennaioli et al. (2014) relate the strength of financial institutions to cross-country capital flows and the governments' decision to default. The authors conclude that better financial institutions increase capital inflows to a country and reduce the attractiveness of government default. Cooper and Nikolov (2013) connect the model of sovereign debt fragility by Calvo (1988) with the model of bank fragility by Diamond and Dybvig (1983) and focus on two channels of mutual contagion: banks' sovereign bond holdings and explicit or implicit government guarantees. They find that a sudden drop in confidence in the sovereign's creditworthiness may abruptly shift the economy to a pessimistic equilibrium associated with a bank run and costly asset liquidation. They also study the role of deposit insurance, which may prevent bank runs but may also exacerbate a looming fiscal crisis, and the government's decision on whether to stick to its commitment towards depositors or not. Motivated by the Irish example, Acharya et al. (2014) study the impact of bank bailouts on sovereign risk. A bailout alleviates the under-provision of financial services due to debt overhang but also provokes distortive taxation of the non-financial sector. The latter can be avoided by a sovereign default, which, however, further weakens the solvency situation of banks. The intimate linkages between financial and sovereign risk are also documented by empirical evidence: Acharya et al. (2014), for example, show that the recent crisis and the corresponding bailouts caused a risk transfer to the government while Battistini et al. (2013) point out the significant home bias of European banks' sovereign bond portfolios and its negative consequences. Similarly, Mody and Sandri (2012) provide evidence for the strong impact of the banking sector's performance on risk premia on euro area sovereign bonds. Furthermore, they highlight that problems in the banking sector exert particularly negative effects in countries with low growth prospects and high initial debt burdens. Reinhart and Rogoff (2011) eventually demonstrate that these insights hold for a long-run perspective as well. Using data from nearly two centuries, they find that sovereign debt crises have been frequently preceded by banking crises in the past.

4.3 The model

This section outlines the baseline model: The main source of risk in the economy is bank loans (e.g. mortgages, consumer or commercial loans, asset-backed securities), which are characterized by a stochastic return: Bad realizations, which may, for example, reflect a large share of non-performing loans or write-offs on asset-backed securities, may cause substantial losses that quickly wipe out a bank's small equity – a feature that captures the asset risk dimension of financial fragility. Bank risk may then spread to the sovereign through two channels – government guarantees and taxation – and may trigger a sovereign default, which, in turn, may exert adverse feedback effects due to the sovereign bond holdings of banks. Sovereign debt fragility is therefore the second source of risk in the economy. It arises due to the interaction of investors' expectations about sovereign risk and the required return on government bonds. Hence, multiple equilibria, which differ in the extent and mechanisms of bank-sovereign contagion, may emerge.

There are two periods and the model economy is populated by three types of *agents*: First, there exists a continuum of measure one of identical *banks*. Each bank is funded by exogenous equity E and raises an amount D of deposits from households, which are protected by a deposit insurance scheme. A bank can invest into two types of assets: (i) bank loans which yield a stochastic return and (ii) sovereign bonds. Importantly, loan returns are correlated across banks to capture the focus on systemic crisis. Bank shareholders are risk-neutral and protected by limited liability; they receive the bank's final-period equity and consume at date 2. Second, risk-averse, identical *households* derive utility from consumption at both dates. They earn labor income modeled as a deterministic endowment at both dates; income is larger at date 1 than at date 2: $W_1 > W_2$. In order to smooth consumption, they deposit savings D with the bank. Third, the *government* assumes two roles: It issues sovereign bonds B to cover exogenous initial expenditures or to roll-over legacy debt; these are purchased by banks and risk-neutral international investors. In order to repay its outstanding obligations, the government raises tax revenue at date 2. Moreover, the government also provides deposit insurance, which is tax-funded and – if actually provided – equivalent to rescue package for distressed banks. The timeline is as follows:

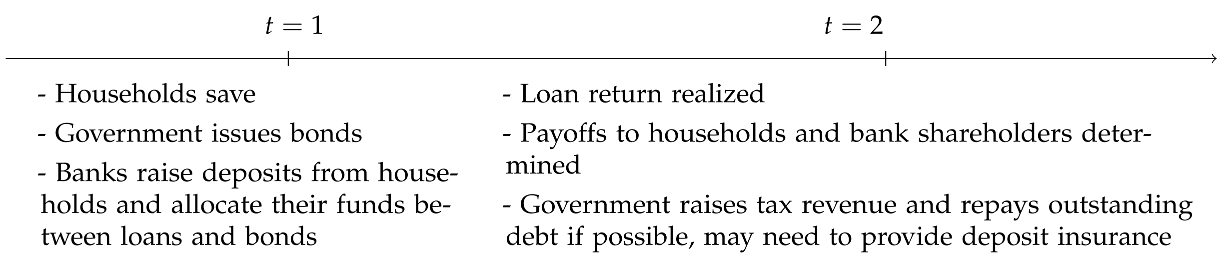

Figure 4.1: Timeline

4.3.1 Banks

The main characteristic of banks in our model is that they operate a risky technology, a feature shared with Dermine (1986) and Boyd et al. (2009), and are endowed with little equity. These models essentially build on a lender-borrower framework à la Jaffee and Modigliani (1969), complemented with the risk of bank failure due to correlated loan returns and an oligopolistic loan market à la Cournot. Motivated by our focus on the bank-sovereign nexus, we replace the risk-free asset in Boyd et al. (2009) by sovereign bonds, the risk-return profile of which endogenously emerges, and include equity to have a richer capital structure. To keep the analysis tractable, however, we rely on perfectly competitive banks and omit an explicit model of borrowers. These twists generate a framework where the bank assumes an active role and allow us to derive novel insights about the mechanisms of contagion as well as the impact of government guarantees.

ASSET ALLOCATION: The bank funds itself by exogenous equity E and deposits D raised from households. Since deposits are insured, they earn the (gross) risk-free interest rate normalized to one. The bank allocates these funds among two assets: First, an amount L is invested in loans that are characterized by assumption 1.

Assumption 1. *Loans yield a stochastic (gross) return, A, per unit; $A \in [0, \bar{A}]$ is distributed according to some continuous twice-differentiable distribution function $F(A)$ with $E(A) = \int_0^{\bar{A}} AdF(A) > 1$. Conditional on bank failure, depositors can recover at most a liquidation value, vA, per unit, where $v \leq 1$.*

Hence, loans are risky and may trigger bank failure in case they perform poorly. They can be interpreted as credit to small businesses that invest in risky projects. Assumption 1 implies that the liquidation of bank loans is costly; $v < 1$ may, for instance, represent a bank run scenario where a shock triggers an immediate, disorderly liquidation of the bank. Assets may then have to be sold at a dislocated price. Alternatively, suppose that loan collection requires specific skills as in Diamond and Rajan (2000). If the bank fails, its owners receive a zero payoff and depositors cannot force them to use the bank's capabilities on their behalf such that they lose a fraction of each loan's value. Second, the bank can purchase an amount G of sovereign bonds with a binary payoff $\widetilde{R}$ which equals $R \geq 1$ (per unit) if the government is solvent (with probability $1 - p$) and zero otherwise (with probability p). The bank observes the return on sovereign bonds R as well as the sovereign default probability p, both of which it takes as given. Since bank shareholders are protected by limited liability and only consider the upside of their bank's investments, the bank maximizes its expected equity value $E[\max\{\pi, 0\}]$ by solving:

Program 1. *The bank chooses loans L, sovereign bonds G, and deposits D to maximize its* *expected equity value*

$$\max_{L,G,D} \int_{A^*}^{\bar{A}} AL + \widetilde{R}G - DdF(A) \tag{4.1}$$

subject to a funding constraint

$$L + G = E + D \tag{4.2}$$

A^* denotes the minimum realization of the loan return A, for which the bank just succeeds (failure threshold):

$$A^* = \max \left\{ \frac{D - \tilde{R}G}{L}, 0 \right\} \tag{4.3}$$

The bank fails as soon as the stochastic loan return falls short of A^*. This threshold crucially depends on sovereign bond repayment; the latter is not exogenous but influenced by the realized loan return. Hence, the bank forms expectations about the bond repayment conditional on its own performance. It evaluates sovereign bonds based on their expected return: If bank and sovereign risks were independent, the bank would simply earn an expected return on bonds equal to $[1 - F(A^*)](1 - p)R$, i.e. the probability that it succeeds times the expected return on sovereign bonds. Since bank loans are the main source of risk in the economy, however, bank and sovereign risks are interconnected. Consequently, the bank determines the asset allocation using the probability of bond repayment conditional on its own survival, $1 - p_C$, instead of the 'true' repayment probability, $1 - p$, such that its expected return on sovereign bonds equals $[1 - F(A^*)](1 - p_C)R$. This distortion arises due to limited liability. Using Bayes' theorem one may write the conditional default probability $p_C = Prob(Bonds\ not\ repaid|Bank\ survives)$ as:

$$p_C = \frac{Prob(Bonds\ not\ repaid,\ bank\ survives)}{Prob(Bank\ survives)} = \frac{\int_{A^*}^{F^{-1}(p)} dF(A)}{1 - F(A^*)} = \frac{\max\{p - F(A^*), 0\}}{1 - F(A^*)}$$

Note that $F^{-1}(p)$ is the critical realization of the stochastic loan return consistent with the sovereign's default probability p. The integral captures all realizations of the loan return for which the bank survives (i.e., $A \geq A^*$) and the government defaults (i.e., $A < F^{-1}(p)$).

TWO CASES: Obviously, two cases exist: If sovereign risk is higher than bank risk (i.e., if $p > F(A^*)$ and $\widetilde{R} = 0$ at $A = A^*$), the conditional probability that bonds are not repaid equals $p_C = \frac{p - F(A^*)}{1 - F(A^*)}$. Therefore, the bank earns an expected bond return of $[1 - F(A^*)](1 - p_C)R = (1 - p)R$. If, in contrast, sovereign risk is lower than bank risk (i.e., if $p \leq F(A^*)$ and $\widetilde{R} = R$ at $A = A^*$), sovereign bonds are always repaid as long as the bank survives and the conditional default probability, p_C, is zero such that the bank essentially considers them risk-free. In this case, banks earn an expected bond return $[1 - F(A^*)]R$. Combining the two cases, the bank's expected bond return equals

$[1-\max\{F(A^*),p\}]R$. Its optimization problem simplifies to:

$$\max_{L,D} \int_{A^*}^{\bar{A}} ALdF(A) + [1-\max\{F(A^*),p\}]R(D+E-L) - [1-F(A^*)]D \tag{4.4}$$

While the first two terms capture the expected returns on loans and bonds, respectively, the third term represents the bank's expected repayment to its depositors. Moreover, one can determine which of the two cases explained above materializes (i.e., whether $F(A^*) \geq p$ or $F(A^*) < p$) based on the sovereign default probability p and the definition of the bank's failure threshold in (4.3): If bonds are repaid (i.e. if the government honors its debt for $A = A^*$), holding them reduces the bank's exposure to loan risk and provides a buffer to partially absorb loan losses. The bank can thus withstand worse (i.e., lower) realizations of A. In this scenario, a bank features the highest possible risk level, which corresponds to $A^* = \frac{D}{D+E}$, in case it does not hold any sovereign bonds but invests in risky loans only (i.e., $L = D+E$ and, by the funding constraint, $G = 0$). If the bonds are not repaid, however, $A^* = \frac{D}{D+E}$ exactly denotes the minimum feasible level of bank risk instead. Again, this level is reached if the bank is exclusively invested in loans. Holding bonds then merely translates into losses that undermine the bank's solvency. One can thus define a critical probability of sovereign default:

$$\bar{p} = F\left(\frac{D}{D+E}\right)$$

Since bank and sovereign risks are interconnected, bond repayment is endogenous and related to banks' risk profile: First, if $p \leq F(A^*)$, bond repayment (i.e., $\widetilde{R} = R$) at $A = A^*$ requires that $p < \bar{p}$. Otherwise, p would exceed the *highest* possible level of bank risk in this case, $\bar{p}$, and contradict the initial assumption that bonds are repaid if the bank succeeds, $p \leq F(A^*)$. Second, if $p > F(A^*)$, no repayment (i.e., $\widetilde{R} = 0$) at $A = A^*$ requires $p \geq \bar{p}$ as p would otherwise lie below the *lowest* possible level of bank risk, $\bar{p}$, again violating the initial assumption. Consequently, the bank's failure threshold can be defined in terms of the sovereign default probability p:

$$A^* = \begin{cases} \max\left\{\frac{D-R(D+E-L)}{L}, F^{-1}(p)\right\}, & \text{if } p \leq \bar{p} \\ \min\left\{\frac{D}{L}, F^{-1}(p)\right\}, & \text{if } p > \bar{p} \end{cases} \tag{4.5}$$

Intuitively, $p \leq \bar{p}$ implies that the bank is at least as vulnerable as the government and that the latter can withstand a worse realization of A. Hence, the bank still receives the bond repayment at the failure threshold (i.e., $\tilde{R} = R$). The reverse is true for $p > \bar{p}$. The bank's failure thresholds depending on bond repayment – $A^*_{|\widetilde{R}=R}$ and $A^*_{|\widetilde{R}=0}$ – are illustrated in figure 4.2. Importantly, a sovereign default shifts up this threshold and weakens the bank's capacity to withstand a poor loan performance. This effect depends on the asset allocation: As long as bonds are repaid, the bank can withstand a worse performance of its loans if it holds more sovereign bonds (lower upward-sloping line); if they are not repaid, the bank becomes more vulnerable if it holds more bonds (upper downward-sloping line). They coincide whenever the bank is only invested in loans. From figure 4.2, one may also conclude that whenever, for a given bond return, the sovereign default threshold $F^{-1}(p)$ is in the area below (above) the lower (upper) of these two curves, bank failure is more (less) likely than a sovereign default as the government withstands a worse realization of the loan return. Moreover, if it lies in the area between the two curves, the bank will survive as long as bonds are repaid (since $A^*_{|\widetilde{R}=R} < A$) but will fail as soon as they are not (since $A^*_{|\widetilde{R}=0} > A$). Hence, the bank fails as soon as the government does not repay the bonds. Such a case captures the idea of an adverse feedback as a sovereign default immediately pushes banks into bankruptcy.

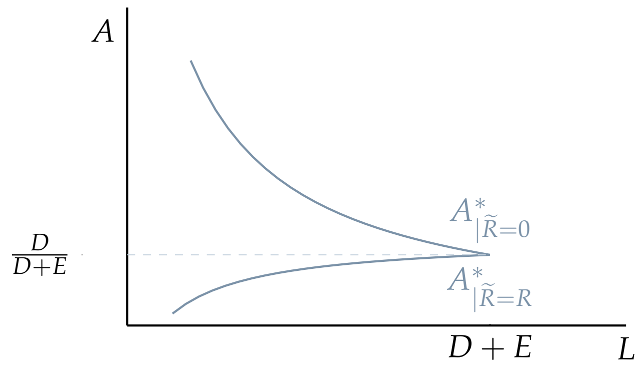

FIGURE 4.2: Bank's failure threshold

One can now solve the bank's optimization problem, (4.4), separately for these two cases using the failure thresholds specified in (4.5). The solution yields optimal bank size and asset allocation. Importantly, the objective function is increasing in deposits in both cases such that the bank's demand for deposits D is indeterminate and perfectly elastic at the prevailing risk-free interest rate, which is normalized to one.[2] As a result, the bank is willing to accept any amount of deposits supplied by households such that its size $D+E$ is predetermined by equity endowment and household savings.[3] Similarly, expected bank profits are a linear or convex function of loans, which implies that no interior maximum $L \in (0, D+E)$ exists. This feature essentially reduces the problem to a binary comparison of expected profits from exclusively investing in either loans ($L = D+E$) or sovereign bonds ($L = 0$). A bank chooses the former as long as $\pi(D+E) \geq \pi(0)$. The results are summarized in:

Lemma 1. *The bank's deposit demand D is perfectly elastic. The cutoff R' is defined as follows:*

[2] This feature that keeps the subsequent analysis tractable arises due to perfect competition for deposits and the absence of any (convex) cost. In Boyd et al. (2009), for example, Cournot competition ensures an interior solution.

[3] Note that the critical default probability $\bar{p}$ is independent of the bank's choices and thus taken as given.

$$R' = \frac{1}{1-p}\left[E(A) + \int_0^{\frac{D}{D+E}} F(A)dA - \frac{pD}{D+E}\right] \tag{4.6}$$

R' decreases in bank equity E if $p < \bar{p}$ but increases if $p > \bar{p}$. The bank holds an amount

$$L = \begin{cases} D+E, & \text{if } R \le R' \\ 0, & \text{if } R > R' \end{cases} \tag{4.7}$$

of loans and purchases an amount $G = D + E - L$ of sovereign bonds. The bank's failure threshold is:

$$A^* = \begin{cases} \frac{D}{D+E}, & \text{if } R \le R' \\ F^{-1}(p), & \text{if } R > R' \end{cases} \tag{4.8}$$

Proof: See Appendix 4.B.

The bank invests in the asset that promises a higher expected return from its own perspective. This choice is graphically illustrated in figure 4.3.1, where the shaded area represents allocations for which the bank decides to exclusively hold loans and R' defines the critical bond return for which the bank is just indifferent between loans and bonds. If sovereign bonds yield a low return given their risk profile, the bank chooses to provide loans. If the return of bonds exceeds R', however, the bank exclusively purchases sovereign bonds.

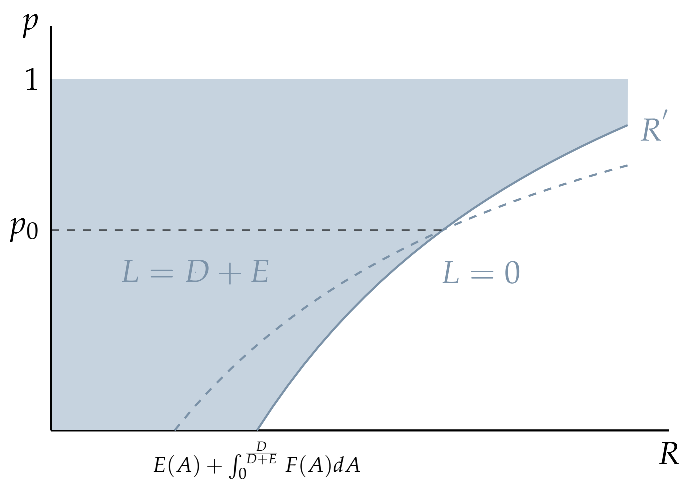

FIGURE 4.3: Bank's asset allocation

CRITICAL RISK-RETURN CUT-OFF: The cut-off critically depends on the two assets' risk-return profile: If the likelihood of a sovereign default p increases, bonds become less attractive and banks are only willing to buy them when they are compensated by a higher return in case of success. In the absence of limited liability, R' would simply be pinned down by the equalization of expected returns, $E(A) = (1 - p)R$, represented by the dashed line in figure 4.3.1. Limited liability, which means that the bank shareholders do not need to repay the deposits in case of failure, distorts this choice. This effect is captured by the second and third term of expression (4.6). As a result, limited liability induces the bank to invest in a riskier asset allocation. More precisely, it distorts this choice at the extensive margin in favor of loans if bonds are relatively safe, $p < p_0 \equiv \frac{D+E}{D} \int_0^{\frac{D}{D+E}} F(A)dA$, and in favor of bonds if loans are relatively safe, $p > p_0$, respectively.

4.3.2 Households

Households consume C_t and earn labor income W_t at both dates, where $W_1 > W_2$. There is no discounting. Since their income at date 1 is higher and households smooth consumption, they save and deposit their savings, D, with the bank. Their date 2-consumption is subject to taxation with tax rate t such that date 2 consumption spending is $(1+t)C_2$. Importantly, households consider deposits as safe and deposit insurance as credible.[4] Deposits earn the (gross) risk-free rate normalized to one such that the household's optimization problem emerges as:

$$\max_D u \underbrace{(W_1 - D)}_{C_1} + Eu \underbrace{\left(\frac{W_2 + D}{1+t}\right)}_{C_2} \tag{4.9}$$

We rely on the logarithmic utility function $u(C_t) = log(C_t)$ to keep the analysis tractable as the tax rate then does not affect households' savings decisions: Income and substitution effect just offset each other such that the choice is independent of the uncertain date 2-tax rate.

Lemma 2. *Due to log utility, savings amount to*

$$D = \frac{W_1 - W_2}{2} \tag{4.10}$$

and do not depend on the tax rate. The consumption profile presents itself as follows:

$$C_1 = \frac{W_1 + W_2}{2} \qquad C_2 = \frac{W_1 + W_2}{2(1+t)}$$

Proof: Follows from the first-order condition of (4.9) using the log utility function. *Q.E.D.*

[4] This is possible since the government has the fiscal capacity to provide it, which is ensured by assumption.

4.3.3 Government

The government's role is essentially shaped by three key characteristics: debt, taxes, and default. First of all, the government issues an exogenous amount B of sovereign bonds at date 1 either to roll over legacy debt or to cover initial expenditures. These bonds promise a gross return R and are sold to domestic banks and to risk-neutral international investors. The former's demand equals G, the latter's is perfectly elastic as long as they earn an expected bond return that equals the risk-free (gross) interest rate:

$$(1-p)R = 1 \tag{4.11}$$

This key condition ensures 'fair' pricing of sovereign bonds. The presence of foreign investors is crucial in this regard as the bank's asset allocation is distorted by limited liability and risk-averse households refrain from buying risky bonds in general.[5] We therefore impose the following assumption on the bond volume B:

Assumption 2. $B > \frac{W_1 - W_2}{2} + E$

This ensures that the amount of available government bonds is large enough to meet the demand of domestic banks even if they invest all their funds in sovereign bonds (i.e., if $G = D + E$) and that a fraction of bonds is held by foreign investors. The share of these securities held by domestic banks is therefore defined as:

$$\omega = \frac{G}{B}$$

Moreover, the government raises taxes from households and bank shareholders at date 2 in order to (i) repay its debt and (ii) to fund the deposit insurance scheme if necessary. In principle, the tax is designed as a consumption tax[6] t but it is subsequently expressed in terms of the equivalent income tax $\tau \in [0, 1]$, which is more intuitive.[7] The tax rate τ is chosen such that it guarantees a balanced budget. It is, however, constrained by an upper bound $\bar{\tau} \leq 1$. $\bar{\tau} = 1$ seems to be a natural maximum for the tax capacity although institutional limitations, tax evasion and other frictions may in fact justify a smaller ceiling. This idea is related to Cooper and Nikolov (2013) although, in their model, the ceiling is stochastic and the very source of sovereign risk. The tax ceiling $\bar{\tau}$ satisfies two conditions:

Assumption 3. $(i)\ \bar{\tau} \geq \frac{2B}{W_1+W_2}$, $\qquad (ii)\ W_2 > E$

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5 To be indifferent between deposits which are considered safe due to deposit insurance, they would require an additional risk premium.

6 This is to keep the analysis tractable. A classical income tax would make deposits sensitive to the tax rate (see section 4.3.2) and require households to correctly anticipate the tax policy depending on bank and sovereign risks.

7 Recall the relationship between τ and the consumption tax t, i.e. $1 - \tau = \frac{1}{1+t}$.

Whereas the former guarantees – in conjunction with assumption 2 – that deposit insurance is feasible and credible even for a complete loss on loans,[8] the latter ensures that $\bar{\tau} \leq 1$ is indeed possible. Yet, the government may eventually default even though it manages to successfully bail-out depositors. This occurs if it fails to raise sufficient tax revenue to cover all cost, namely, deposit insurance and outstanding debt. Importantly, default entails a full haircut on sovereign bonds, which is a common assumption in related models such as Cooper and Nikolov (2013). Deposit insurance, in contrast, is still provided if necessary.

The very reason of a sovereign default is therefore the government's two-way exposure to the risky banks loans: After all, loan performance (i.e., the realization of the stochastic return A) influences (i) date 2-consumption of bank shareholders and, thus, the tax base as it determines the dividend payout as well as (ii) the cost of providing deposit insurance in case of bank failure. Hence, a sovereign default eventually occurs due to weak fundamentals rather than strategic considerations like in Calvo (1988). One can derive a precise sovereign default threshold $\hat{A}$: The government repays its debt if the bank's loans perform better than $\hat{A}$ and defaults otherwise. This threshold determines the default probability p:

$$p = F(\hat{A}) \tag{4.12}$$

DEFAULT CASES: First of all, suppose that the bank survives because its loan portfolio performs well (i.e., $A \geq A^*$). Deposit insurance is not needed in such a scenario and the government's date 2 expenditures entirely consist of the debt repayment. Taxes are levied on consumption spending of both households, $W_2 + D$, and bank shareholders, $AL + RG - D$, such that the tax rate follows from the balanced budget condition:

$$BR = \tau[AL + R(D + E - L) + W_2] \tag{4.13}$$

As soon as the level of τ implied by this condition exceeds the ceiling $\bar{\tau}$, the government defaults because it would need to impose an unfeasibly high tax rate to collect sufficient revenue. The reason for that is the low tax base due to insufficient dividend income of bank shareholders. Substituting for τ in expression (4.13) yields the sovereign default threshold:

$$\hat{A}_{|A \geq A^*} = \max\left\{\frac{D - R(D + E - L)}{L} + \frac{BR - \bar{\tau}(D + W_2)}{\bar{\tau}L}, 0\right\} \tag{4.14}$$

Second, suppose that banks fail due to poor loan performance (i.e., $A < A^*$). The government incurs cost of deposit insurance which equal guaranteed deposits net of

[8] In an extreme case where loans completely fail and sovereign bonds are not repaid, the cost of deposit insurance is D. Substituting for B in the first inequality using assumption 2; maximum date 2 tax revenue $\bar{\tau}(D + W_2)$ exceeds the cost.

the residual value of bank assets:

$$DC(A) = D - AL - R(D + E - L) \tag{4.15}$$

Added to the bond repayment, they constitute the second component of the government's date 2 expenditures. The balanced budget condition that pins down the tax rate therefore equals:

$$BR + DC(A) = \tau(D + W_2) \tag{4.16}$$

Again, the government defaults whenever $\tau \geq \bar{\tau}$. But as opposed to (4.13) above, the constellation is now relatively worse since the tax base is lower and depositors have to be bailed out. Combining (4.15) and (4.16) yields the sovereign default threshold:

$$\hat{A}_{|A<A^*} = \max\left\{\frac{D - R(D + E - L)}{L} + \frac{BR - \bar{\tau}(D + W_2)}{L}, 0\right\} \tag{4.17}$$

DEFAULT THRESHOLDS: The government's default threshold $\hat{A}$ as well as the bank failure threshold A^*, which follows from (4.5), are illustrated by the blue and red lines in figure 4.4, respectively. This reveals the existence of three possible outcomes: First, the government tends to be relatively more stable than banks (i.e., $\hat{A} < A^*$) whenever the interest rate on its debt imposed by foreign bondholders is relatively low and falls short of the cutoff R_0. This corresponds to classical bank-sovereign contagion as a poor loan performance causes bank failure, which may eventually trigger a sovereign default because of deposit insurance cost. Second, the government is less stable than banks (i.e., $\hat{A} > A^*$) in case the bond return is relatively large and exceeds the cutoff R_1. This represents an outcome where the debt burden is so large that the government may even default in the absence of bank failure; low bank dividends and tax revenue are sufficient to trigger a sovereign default. Third, there can exist an interim region, $R_0 < R < R_1$, where bank and sovereign risks coincide. In such an outcome, banks *per se* would survive for the loan return $A = \hat{A}$ but fail as soon as they incur additional losses on their sovereign bond holdings. This captures an adverse feedback that arises because a mediocre loan performance directly leads to a sovereign default, which, in turn, puts banks in jeopardy.

Note that these three cases exactly correspond to those stressed in the context of figure 4.2 but are now characterized in terms of the bond return.[9] It can be shown that the default threshold $\hat{A}$ is described by (4.17) for $R \leq R_0$ and by (4.14) for $R > R_0$. Graphically, the corresponding curves described intersect at the cutoff $R = R_0$; the sovereign default threshold represented by the solid blue line has a kink but is continuous. Both cutoffs are obtained from $\hat{A} = A^*$, that is, equalizing (4.17) and

9 A summary of these cases can be found in appendix 4.C.

$A^* = \frac{D-R(D+E-L)}{L}$ as well as (4.14) and $A^* = \frac{D}{L}$. Using $G = \omega B$ yields:

$$R_0 = \frac{\bar{\tau}(D + W_2)}{B} \tag{4.18}$$

$$R_1 = \frac{\bar{\tau}(D + W_2)}{(1 - \omega\bar{\tau})B} \tag{4.19}$$

Note that $R_0 > 1$ is due to the first part of assumption 3. Obviously, these two cutoffs coincide in case banks do not hold any sovereign bonds (i.e., $\omega = 0$): In such a case, the third outcome, which entails an adverse feedback, vanishes as banks are not exposed to sovereign risk at all. The latter scenario is, in contrast, more likely to be an equilibrium outcome if banks hold a large share of sovereign bonds (i.e., ω and R_2 are large).

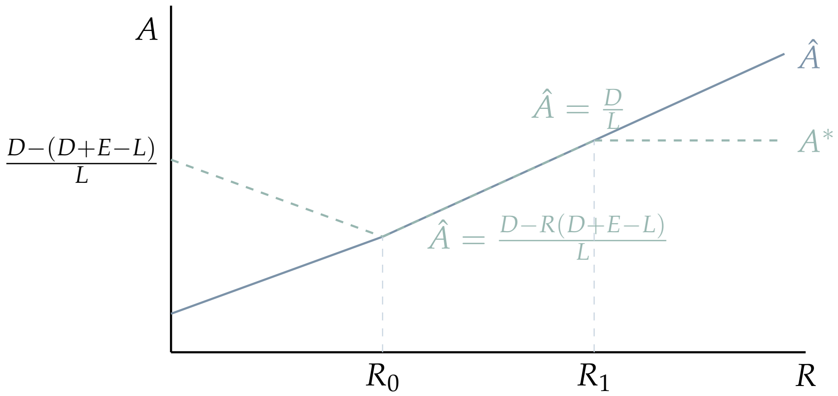

FIGURE 4.4: Sovereign default threshold

With these considerations in mind, one may rewrite the government's default threshold as

$$\hat{A} = \begin{cases} \frac{D-R(D+E-L)}{L} + \max\left\{\frac{BR-\bar{\tau}(D+W_2)}{L}, \frac{BR-\bar{\tau}(D+W_2)}{\bar{\tau}L}\right\}, & \text{if } R \leq R_2 \\ \bar{A}, & \text{if } R > R_2 \end{cases} \tag{4.20}$$

where $R_2 = \frac{\bar{\tau}[\bar{A}L+W_2]}{(1-\omega\bar{\tau})B}$ denotes the bond return above which the government defaults with certainty (i.e., it defaults even if the maximum loan return $\bar{A}$ is realized). Note that the first term in curly brackets is relevant if $R \leq R_0$ while the second expression is applicable for $R > R_0$. Obviously, in both cases, the sovereign default threshold positively depends on the debt burden BR and the size of the commitment to deposit insurance D, but negatively on the tax capacity $\bar{\tau}$ and the bank's assets L and $G = D + E - L$, which effectively reduces the costs of providing deposit insurance by raising the bank's liquidation value.

4.4 Equilibrium analysis

4.4.1 Equilibrium allocation

Combining the optimal decisions of banks and households as well as the government's policy establishes the following proposition:

Proposition 1. *The equilibrium allocation* $\{A^*, \hat{A}, D, G, L, p, R, R'\}$ *is characterized by conditions (4.2), (4.6)-(4.8), (4.10)-(4.12), and (4.20). From (4.20), the sovereign default threshold for* $L = D + E$ *is*

$$\hat{A}_{|L=D+E} = \begin{cases} \frac{D}{D+E} + \max\left\{\frac{BR-\bar{\tau}(D+W_2)}{D+E}, \frac{BR-\bar{\tau}(D+W_2)}{\bar{\tau}(D+E)}\right\}, & \text{if } R \leq R_2 \\ \bar{A}, & \text{if } R > R_2 \end{cases} \tag{4.21}$$

with $R_2 = \frac{\bar{\tau}[\bar{A}(D+E)+W_2]}{B}$. *Two types of equilibria may exist:*

- *The 'good' equilibrium with* $p_g < 1$ *and* $R_g < R_2$ *exists if (i)* $\exists R \in [1, R_2)$ *such that* $F[\hat{A}_{|L=D+E}(R)] \leq 1 - \frac{1}{R}$ *and*
  (ii) $F[\hat{A}_{|L=D+E}(R_g)] \leq \frac{D+E}{D}\left[E(A) + \int_0^{\frac{D}{D+E}} F(A)dA - 1\right]$.
- *The 'bad' equilibrium with* $p_b = 1$ *and* $R_b \to \infty$ *always exists.*

In each equilibrium, banks exclusively invest in loans such that $L = D + E$, $A^* = \frac{D}{D+E}$, *and* $\hat{A} = \hat{A}_{|L=D+E}$.

Proof: See Appendix 4.B.

MULTIPLE EQUILIBRIA: Multiple equilibria arise because investors' expectations about a sovereign default determine their required bond return, which, in turn, influences the government's debt-servicing cost and its default probability. Such dynamics may turn into a self-fulfilling prophecy, which eventually results in one of the equilibria outlined in proposition 1. This is a standard occurrence in many models of public debt crises as exemplified in Romer (2001) and Cooper and Nikolov (2013). In our model, however, the uncertainty about the government's ability to repay originates from risky bank assets that either affect government expenditures or tax revenue rather than a shock to the sovereign's fiscal position itself.

The bank's asset allocation (4.7), the bond pricing equation (4.11), and the sovereign default threshold (4.20) pin down three unknowns that characterize the equilibrium: bank loans L, bond return R, and sovereign default probability $p = F(\widehat{A})$. While the first determines the bank's asset allocation depending on bond characteristics, the second ensures the fair pricing of bonds given investors' expectations about sovereign risk, and the third determines the government's default threshold depending on bond return and banks' asset allocation.

Figure 4.5 illustrates a combination with two equilibria given a bell-shaped density function:[10] The 'good' equilibrium is characterized by a low bond return R_g and a moderate default probability p_g. The 'bad' equilibrium features an infinitely high bond return for which the government defaults with certainty (i.e., $R_2 \to \infty$ and $p_b = 1$). The stability of these equilibria is consistent with the sovereign debt model of Romer (2001). Note that an additional equilibrium with intermediate bond return and default probability may exist conditional on the existence of the 'good' equilibrium. It is, however, unstable under plausible dynamics. Both equilibria are located in the shaded area above R', where banks prefer to invest in loans such that sovereign bonds are purchased by international investors only. Graphically, an equilibrium is determined by the intersection of bond pricing and default curve $p(R)$ and $F(\hat{A})$. The latter is a simple transformation of the default threshold $\hat{A}$ illustrated in figure 4.4.

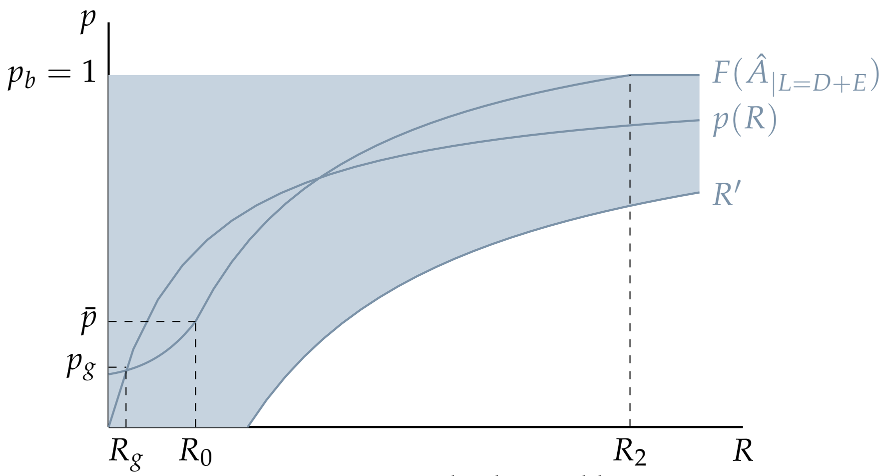

FIGURE 4.5: Multiple equilibria

The result that a bank, which is unconstrained by any regulatory requirements, never purchases fairly priced, domestic sovereign bonds is one of the key insights of the baseline model and requires some comments: Sovereign bonds would need to yield a relatively high return ($R > R'$) in order to be more attractive than loans (i.e., to yield a higher expected return taking into account all effects of limited liability). Since foreign investors price government bonds fairly, however, such a high return would only be consistent if sovereign risk is comparatively high as well. As soon as banks only hold sovereign bonds, though, there is no risk in the economy, and the sovereign default probability equals zero implying a low bond return.[11] An equilibrium with sufficiently

10 Depending on the shape of the distribution function, more than two stable equilibria might exist (see Cooper and Nikolov (2013)) for a graphical illustration). The additional equilibria share features of the 'good' type.

11 Nevertheless, the 'bad' equilibrium may still exist but banks then exclusively hold loans.

attractive bond returns from the bank's perspective is, therefore, inconsistent with the fair pricing condition imposed by bond investors.

Yet, we observe considerable sovereign bond holdings of the banking sector and a significant home bias in reality. This can be explained by several factors: First, deviations from fair pricing of bonds may offer attractive returns, at least temporarily. Central bank stimuli and other demand-side effects currently serve as important examples. Second, capital[12] and liquidity requirements may limit the lending capacity and force the bank to (partly) invest in alternative assets that might be associated with lower returns. In the Basel accords, for instance, sovereign bonds are generally considered as safe such that their risk weight is zero; they are also eligible for the new liquid asset requirements. Third, sovereign bonds play an important role as a collateral for interbank borrowing and repo transactions, which provides another rationale for banks to invest.[13]

Intuitively, a country is likely to end up in the *'good' equilibrium* whenever it is fiscally sound, i.e. when its public debt level B is low or the tax capacity $\bar{\tau}$ high. Optimistic expectations about the sovereign's creditworthiness then translate into a constellation with low debt-servicing cost. As in both equilibria, the bank exclusively invests in loans, defaults with probability $\bar{p}$ and – depending on whether $R_g < R_0$ as illustrated in figure 4.5 or not – may be more ore less stable than the government. In particular, the adverse feedback outcome discussed above is ruled out in the baseline allocation. The 'good' equilibrium exists as long as bond returns R exist, for which (i) the default lies below the bond pricing curve and the (ii) the bank prefers loans to bonds as $R \leq R^{'}$. This holds true if the country is fiscally sound (i.e., low debt, high tax capacity) such that its default probability implied by the threshold $\hat{A}$ is small for low bond returns. Sovereign risk may even vanish in the 'good' equilibrium if the amount of outstanding bonds and deposit insurance obligations is lower than the potential tax income at date 2 even for a complete loss on loans, i.e. if $B + D \leq \bar{\tau}(D + W_2)$ such that the default threshold is $\hat{A} = 0$ for $R = 1$ and sovereign bonds are risk-free.

The *'bad' equilibrium*, in contrast, materializes when a self-fulfilling spiral of pessimism translates into an excessively high bond return such that the government defaults with certainty. Given that bonds are never repaid in this scenario, however, no investor is willing to purchase them in the first place. Since the bank is exclusively invested in loans anyway, it is always more stable than the government (i.e., $A^* < \hat{A} = \bar{A}$).[14] The 'bad' equilibrium is particularly relevant as soon as the 'good' does not exist: This may occur, for instance, in case of a highly indebted country with an insufficient tax capacity. Hence, its actual default probability exceeds the default probability implied

12 Capital regulation is explored in section 4.5.

13 See Bolton and Jeanne (2011) for a model of interbank borrowing with risky sovereign bonds.

14 The government can still collect sufficient revenue to provide deposit insurance due to assumption 3.

by fair bond pricing for all finite values of R. Graphically, this means that default and bond pricing curve never intersect and only coincide in the limit.

4.4.2 Bank and sovereign risks

Since banks exclusively hold loans in equilibrium, they are not exposed to sovereign risk and thus insensitive to fiscal fundamentals. They fail whenever loans perform so poorly that their date 2 equity is wiped out and deposits are not covered anymore. Hence, the failure threshold equals the leverage ratio:

$$A^* = \frac{D}{D+E}$$

Obviously, bank risk increases in leverage, that is, it increases in deposits $\frac{\partial A^*}{\partial D} > 0$, and decreases in equity, $\frac{\partial A^*}{\partial E} < 0$. The latter provides a buffer to absorb loan losses and unambiguously lowers bank risk.

Sovereign risk, in contrast, crucially depends on banks' loan performance and capital structure. Recall that there are two different cases how an equilibrium may emerge: First, banks may be more vulnerable than the government ($A^* \geq \hat{A}$). This is the case whenever the latter is fiscally sound such that it pays low interest rates in equilibrium, $R_g < R_0$, as illustrated in figure 4.5. Contagion then runs from the banking sector to the government and is driven by the cost of deposit insurance or rescue packages as it recently happened in Ireland and Spain. Second, banks may be more stable than the government ($A^* < \hat{A}$). This always occurs in the 'bad' equilibrium and can also be a property of the 'good' one if the debt servicing cost are rather high such that $R_g > R_0$. The tax potential of households is quite small in this scenario compared to the public debt level B. Bank-sovereign contagion then occurs because loans do not perform well enough such that bank dividends and, thus, the tax base are low. As a result, the government cannot raise sufficient revenue to repay its outstanding debt. This may, to some extent, capture the case of highly indebted countries like Italy and Greece, in which the tax base has often been small due to tax evasion and lax fiscal authorities. In general, the government defaults as soon as the necessary tax rate to cover date 2 expenditures (debt repayment BR and possibly deposit insurance cost DC) is no longer feasible. Its default threshold $\hat{A}$ follows directly from condition (4.21). Importantly, a sovereign default involves a full haircut on sovereign bonds whereas deposit insurance is still provided. The sensitivities of default probability $p = F(\hat{A})$ and bond return R can be summarized as follows:

Corollary 1. *In the 'good' equilibrium, the sensitivities of the sovereign default probability are as follows:* $\frac{\partial p}{\partial \bar{\tau}} < 0$, $\frac{\partial p}{\partial B} > 0$, *and* $\frac{\partial p}{\partial E} < 0$; *these imply* $\frac{\partial R}{\partial \bar{\tau}} < 0$, $\frac{\partial R}{\partial B} > 0$, *and* $\frac{\partial R}{\partial E} < 0$. *Sovereign risk decreases in the tax capacity and bank equity but increases in the public debt burden.*

Proof: See Appendix 4.B.

A higher tax capacity, a lower public debt burden, and a banking sector funded by more equity reduce sovereign risk in the 'good' equilibrium and thus depress its debt-servicing costs. This result is not surprising: A sound fiscal policy and a well-capitalized banking sector are widely considered to improve a country's fiscal stability. This is due to the fact that – in equilibrium – default probability and bond return need to be compatible with each other: If public debt B increases, for instance, the default probability rises as well. The bond return then adjusts upwards until it is consistent with the higher sovereign risk.

4.4.3 Deposit insurance and sovereign risk

Interestingly, one can make use of this model to show why government guarantees may either preserve fiscal stability by preventing costly bank failures or jeopardize it by putting the government itself into distress. The latter was, for instance, the case in Ireland and, to a lesser extent, in Spain. For that purpose, we compare sovereign risk in the baseline model where deposit insurance is provided whenever necessary with sovereign risk in a hypothetical scenario in which the government deviates from its commitment and does not rescue distressed banks. The latter describes a relevant alternative to rescue packages, which were frequently employed in the current crisis; Cyprus serves as a recent example. Yet, deposits were considered as safe becasue the explicit or implicit government guarantees in place were mostly considered as credible. Hence, focusing on an *ex post* deviation from the guarantee better captures the alternative than an allocation without deposit insurance at all. While the sovereign default threshold in baseline model is given by (4.20), the default threshold without deposit insurance, $\hat{A}_N$, is subsequently determined by

$$BR = \bar{\tau}[\underbrace{D + W_2}_{Households'\ Inc.} + \underbrace{\hat{A}_N(D+E) - D}_{Bankers'\ Inc.}] \tag{4.22}$$

or

$$BR = \bar{\tau}[\underbrace{W_2 + v\hat{A}_N(D+E)}_{Households'\ Inc.}] \tag{4.23}$$

depending on whether banks are solvent at $A = \hat{A}_N$. These conditions follow from the government's date 2 budget constraint. The solvency of banks matters because the assets' liquidation value is smaller than one ($v < 1$) in the absence of deposit insurance as described for assumption 1. This may be rationalized by a bank run that requires an immediate and costly liquidation of the assets. The default threshold for a government that deviates from its initial commitment follows from (4.22) and (4.23):

$$\hat{A}_N = \begin{cases} \frac{BR - \bar{\tau}W_2}{v\bar{\tau}(D+E)} & \text{if } R < \max\{R_0 - \frac{\bar{\tau}(1-v)D}{B}, 1\} \\ \frac{D}{D+E} & \text{if } \max\{R_0 - \frac{\bar{\tau}(1-v)D}{B}, 1\} \leq R < R_0 \\ \hat{A}, & \text{if } R_0 \leq R \end{cases} \tag{4.24}$$

The discontinuity is entirely due to $v < 1$, which causes a further erosion of the tax base as soon as banks fail. In fact, the liquidation costs associated with bank failure are the very reason for a sovereign default if $R \in \left[R_0 - \frac{\bar{\tau}(1-v)D}{B}, R_0\right]$. For $R \geq R_0$, the thresholds with and without deposit insurance just coincide as the government defaults because of insufficient tax revenue and is more vulnerable than banks anyway. Accordingly, a government that deviates defaults with probability $p_N = F(\hat{A}_N)$. Note that sovereign bonds are not fairly priced *ex post* in such a scenario.

Interestingly, it is not *a priori* clear how the provision of deposit insurance influences sovereign risk. This is because there are two countervailing effects. The choice to refrain from a bailout spares important expenses but also triggers considerable liquidation costs captured by $v < 1$, which reduces the tax base. The magnitude of the latter is thus crucial for the impact of deposit insurance on sovereign risk.

Proposition 2. *Deposit insurance lowers sovereign risk (i.e., $p < p_N$) if the loan liquidation value v is sufficiently small:*

$$v < \min\left\{\frac{BR - \bar{\tau}W_2}{\bar{\tau}(BR - \bar{\tau}W_2 + (1-\bar{\tau})D)}, 1\right\} \equiv v_m(R) \tag{4.25}$$

In the 'good' equilibrium both cases are possible; in the 'bad' equilibrium $p = p_N$ holds irrespective of v.

Proof: See Appendix 4.B.

Proposition 2 is illustrated in figure 4.6: In the shaded area, the liquidation value of bank loans is small ($v \leq v_m$) such that providing deposit insurance indeed prevents a massive erosion of the tax base because liquidation costs would cause a significant drop in household income and tax revenue otherwise. Government guarantees therefore reduce sovereign risk ($p < p_N$). If the liquidation value is large, in contrast, this effect is only moderate and and outweighed by the cost of deposit insurance that may even jeopardize fiscal stability ($p > p_N$). For $R \leq R_0$, the commitment towards deposit insurance thus tends to reduce sovereign risk as long as liquidation cost are sizable or debt-servicing cost are high. If, in equilibrium, $R > R_0$, however, the government defaults irrespective of bank failure such that sovereign risk is independent of the provision of deposit insurance. Intuitively, the fiscal state is so weak that the cost of deposit insurance are small compared to the debt burden.

Figure 4.7 shows two examples that illustrate the impact of deposit insurance on sovereign default. τ and τ_N are the necessary tax rates to cover the government's outstanding obligations as a function of the loan performance, A, depending on whether the government honors its guarantees. The tax rate decreases in A because higher loan returns increase the available resources (i.e., the tax base) or reduce the cost of deposit insurance. Recall that the sovereign default threshold, $\hat{A}$, is determined

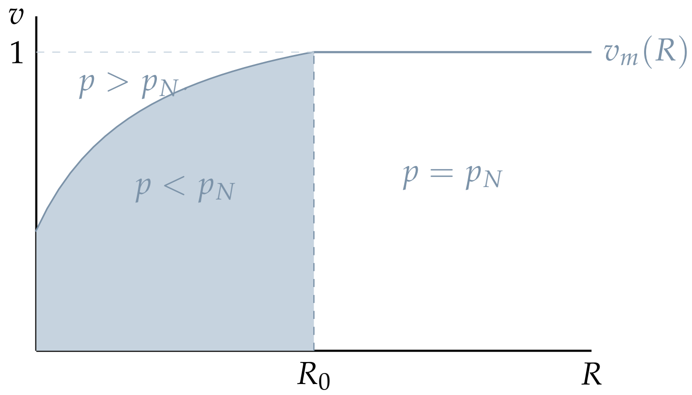

FIGURE 4.6: Deposit insurance and sovereign risk

by the intersection of τ and the maximum feasible tax rate $\bar{\tau}$. The left-hand panel illustrates a scenario where deposit insurance triggers a sovereign default: If the realized bond return is between $\hat{A}_N$ and $\hat{A}$ (in the blue-shaded area), fulfilling the commitment towards depositors requires a tax rate τ that is infeasible such that the government defaults. Providing no deposit insurance, in contrast, requires a tax rate τ_N that is still below the ceiling $\bar{\tau}$. Such a scenario may occur if the liquidation value of bank loans is large ($v > v_m$ in figure 4.6). In the right-hand panel, in contrast, providing deposit insurance prevents a sovereign default if loan return A is between $\hat{A}$ and $\hat{A}_N$. This is due to a small liquidation value ($v < v_m$ and $R < R_0$ in figure 4.6), which would lead to a massive erosion of tax base and revenue in the absence of government guarantees.

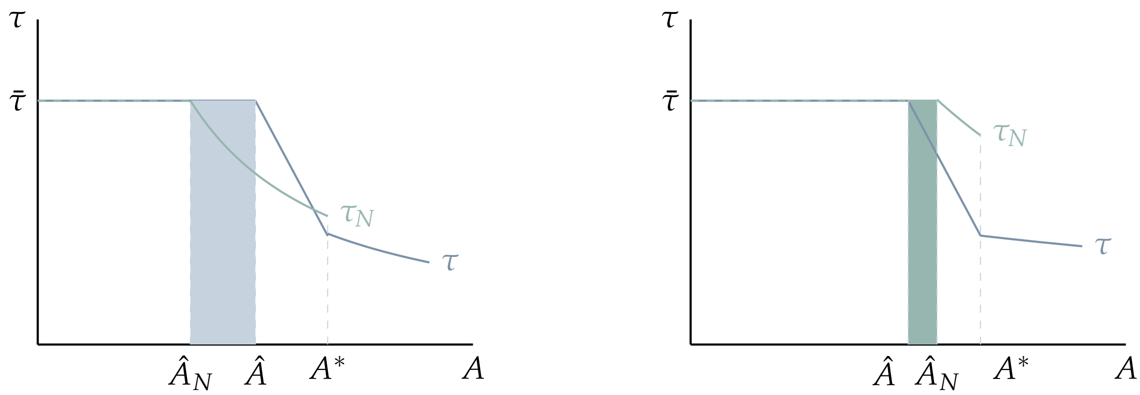

FIGURE 4.7: Default mechanisms and deposit insurance

4.4.4 Deposit insurance and welfare

Another closely associated issue about government guarantees and rescue packages is whether they are welfare-improving: We focus on the question of whether it is efficient to provide deposit insurance in case the bank fails or whether a deviation from the initial commitment can raise domestic welfare.[15] Since households' savings and, thus, their date 1 consumption are independent of an *ex post* decision on whether to satisfy the commitment or not, it is sufficient to look at date 2 domestic welfare, which consists of households' and bankers' utility derived from consumption:

$$V_2 = u(C_2^H) + C_2^B$$

In principle, we compare two welfare profiles at date 2, namely, domestic welfare with and without deposit insurance. For that purpose, however, it suffices to compare the consumption levels.

4.4.4.1 Consumption profile

We first characterize aggregate consumption at date 2, which consists of households' and bankers' consumption $C_2 = C_2^H + C_2^B$: Due to non-linearities associated with default and policy interventions, C_2 is a non-continuous function of the stochastic loan return A.

SCENARIO 1: If the government provides deposit insurance and bails out distressed banks, aggregate consumption equals $C_2 = [1 - \tau(A)][D + W_2 + \max\{A(D+E) - D, 0\}]$. Recall that bankers consume only as long as $A > A^*$. After substituting for the tax rate τ using the government's budget constraints (4.13) and (4.16), one obtains:

$$C_2 = \begin{cases} W_2 + A(D+E) - BR & \text{if } A \geq \hat{A} \\ W_2 + A(D+E) & \text{if } A < \hat{A} \end{cases} \tag{4.26}$$

Hence, aggregate consumption equals total income net of public debt. Importantly, the discrete jump at the sovereign default threshold $\hat{A}$ results from the full haircut on public debt, which reduces the tax burden as well as the tax rate at date 2 thereby raising domestic consumption. The tax rate[16] may, however, still be positive in case the government needs to finance its deposit insurance scheme. This consumption profile generally emerges in both equilibria. In the 'bad' equilibrium, however, the government defaults first, which implies that there is no public debt that needs to be repaid at date 2. Aggregate consumption is then fully described by the second part of (4.26) since $\hat{A} = \bar{A}$.

SCENARIO 2: If the government deviates from its initial commitment and does not provide deposit insurance, its (potential) expenditures at date 2 only come to BR. Compared to the scenario above, consumption differs in two fundamental ways: First,

[15] We again focus on an *ex post* deviation instead of a scenario without deposit insurance at all as it is consistent with the fact that investors and depositors often indeed expected governments to rescue distressed banks.

[16] Assumption 3 ensures that it never exceeds $\bar{\tau}$.

the default threshold changes to $\hat{A}_N$ given by (4.24); second, liquidation costs reduce the value of the bank's assets to v per unit as soon as the bank fails (i.e., if $A < A^*$). While the former affects consumption indirectly because of taxation, the latter reduces income and consumption directly. After substituting for the tax rate τ_N using the government's budget constraints (4.13) and (4.16), the following consumption profile arises:

$$C_2^N = \begin{cases} W_2 + [1 - \mathbb{1}_{A<A^*}(1-v)]A(D+E) - BR & \text{if } A \geq \hat{A}_N \\ W_2 + [1 - \mathbb{1}_{A<A^*}(1-v)]A(D+E) & \text{if } A < \hat{A}_N \end{cases} \tag{4.27}$$

The term in square brackets equals one if the bank succeeds and v otherwise such that loans are worth only $vA(D+E)$ in case the bank fails in a disorderly way.

4.4.4.2 Welfare implications

Deposit insurance therefore affects consumption and welfare in two ways: (i) by preventing a costly liquidation of the bank's assets and (ii) through its effect on the sovereign default threshold. While the former always increases consumption, the effect of the latter is ambiguous and strongly depends on how guarantees affect sovereign risk (see proposition 2). A binary comparison of the two consumption profiles C_2 and C_2^N yields the following corollary:

Corollary 2. *If in equilibrium (i) $R \geq R_0$ or (ii) $R < R_0$ and $v \geq v_m(R)$, deposit insurance can always increase domestic welfare. If (iii) $R < R_0$ and $v < v_m(R)$, the welfare effect depends on the realization of A: It can be positive for $A \notin [\hat{A}, \hat{A}_N]$ but is negative for $A \in [\hat{A}, \hat{A}_N]$.*

Proof: This follows from the comparison of the consumption profiles (4.26) and (4.27) using the default threshold $\hat{A}_N$ given by (4.24). The positive effect in (i) and (ii) is due to $\hat{A} \geq \hat{A}_N$. To show (iii), one compares (4.26) and (4.27): The result is $C_2 > C_2^N$ for $A < \hat{A}$ and $A \in (\hat{A}_N, A^*)$ due to $v < 1$ and $C_2 < C_2^N$ for $A \in [\hat{A}, \hat{A}_N]$. The latter requires $BR > (1-v)A(D+E)$ which follows from the last inequality after substituting for consumption. If satisfied for the maximum value $A = \hat{A}_N$, this relation is obviously true for all $A \in [\hat{A}, \hat{A}_N]$: $\hat{A}_N$ is at most $\frac{D}{D+E}$ such that $BR > (1-v)D$. This is ensured by assumption 2, which requires $B > D$. *Q.E.D.*

One can relate these cases to the three regions in figure 4.6: In the first case, which corresponds to the region $p = p_N$, the provision of deposit insurance does not affect the government's default threshold such that $\hat{A}$ and $\hat{A}_N$ coincide. It can still be welfare-improving if a bank failure would imply positive liquidation costs (i.e., if $v < 1$). If depositors can recover the full liquidation value of the bank's assets ($v = 1$), however, deposit insurance is essentially a zero-sum game because the costs increase the tax burden one-to-one without affecting consumption. In the second case, which is highlighted by region $p > p_N$, providing deposit insurance increases domestic consumption as it (i) prevents costly liquidation and (ii) raises sovereign risk thus shifting the cost of deposit insurance onto foreign bondholders. In the third case, as indicated by the region $p < p_N$, however, these effects have opposite signs: While preventing costly liquidation is still welfare-improving, providing deposit insurance makes a sovereign default less likely. Hence, there are fewer opportunities to remove the debt burden. The second, negative effect dominates whenever present, that is, if loan performance is such that government guarantees indeed prevent a sovereign default, $A \in [\hat{A}, \hat{A}_N]$. This is shown by the shaded area in the right-hand panel of figure 4.7. The intuition is that loans are performing quite poorly. The positive effect of preventing additional liquidation costs, which are proportional to the loans' realized value, is thus dominated by the negative effect of not shifting the public debt burden to foreign investors. If A is outside this region, however, a sovereign default does not depend on deposit insurance such that only the positive effect of recovering the full asset value exists.

The welfare implications of government guarantees crucially depend also on the type of equilibrium. In the 'bad' one, where sovereign default occurs with certainty and $R > R_0$, the first of the three cases matters. Fulfilling the commitment to depositors is welfare-improving only in the presence of liquidation cost and a zero-sum game, where deposit insurance is essentially paid by the households themselves through higher taxes, otherwise. In the 'good' equilibrium, however, deposit insurance may become a decisive factor for both sovereign and domestic welfare.

Moreover, the welfare properties of deposit insurance may also have implications for the credibility of deposit insurance: In the first two cases, rescuing distressed banks is always optimal *ex post* such that a benevolent government will indeed rescue a failing bank. Deposit insurance is then both time-consistent and credible. As a side effect, it could be argued that the disciplining role of depositors through the threat of bank runs – as claimed in Diamond and Rajan (2000), for example – can therefore not be rationalized under such circumstances. In the third case, however, the government might have an incentive to deviate from its initial commitment depending on the performance of bank loans. Deposit insurance could be time-inconsistent in such a scenario but is still provided due to legal obligations. Agents may otherwise anticipate that the commitment might not be fulfilled and revise their expectations. Households, for instance, might demand a risk-adjusted deposit interest rate while investors would impose a different bond return due to implications of deposit insurance for sovereign default.

Eventually, the finding of a potentially welfare-improving sovereign default requires some comments. It is clear that the possibility to remove the debt (and tax) burden by defaulting on bonds that are exclusively held by foreign investors in equilibrium raises domestic consumption and welfare. Importantly, however, a default in our model only occurs due to bad fundamentals, namely, if the government cannot collect sufficient revenue to cover all its date 2 expenditures. This sets it apart from contributions, which model default as a strategic decision. In our model, defaulting on bonds would then always be optimal *ex post* regardless of the fiscal capacity such that only the 'bad' equilibrium would prevail. The result that sovereign default is welfare-improving should, however, be interpreted with some caution for several reasons. First, a static framework does not capture negative future effects such as damaged reputation and limited access to the international capital market. Second, a sovereign default may entail high macroeconomic and political costs, for example, employment losses in the public sector, political instability or social unrest. This could be easily added to the model either as reduced-form social cost or – following Cooper and Nikolov (2013) – as lower date 2 labor income W_2.[17] Third, a considerable fraction of sovereign bonds is often held by domestic investors such as banks, pension funds, insurance companies. The domestic welfare gain of defaulting on these bonds is likely to be smaller in reality. Fourth, a default implies a full haircut on bondholders, while the residual remains with the government.

4.5 Capital regulation

The bank's asset allocation has been unconstrained in the model so far. In reality, however, banks face numerous regulatory restrictions, one of the most relevant constraints are capital requirements, which motivate this extension. A key ingredient of this model is that they limit the bank's lending capacity but do not constrain sovereign bond holdings due to positive risk weights for the former and zero risk weights for the latter. Consequently, capital regulation is one factor that can explain why banks purchase fairly priced sovereign bonds in equilibrium. Such bond holdings provide a richer characterization of the bank-sovereign nexus: While the two main channels of bank-sovereign contagion – government guarantees and taxation – still prevail in such an allocation, a scenario with adverse feedback loops can now occur as well. This happens if banks fail or are considerably more vulnerable because of a sovereign default. Besides such a case, banks can also be sensitive to fiscal fundamentals such as public debt or tax capacity because the bond return, which reflects sovereign vulnerability, becomes a critical determinant of bank risk.

4.5.1 Banks

Due to capital requirements, banks need to finance a fraction of their loans by equity whereas sovereign bonds have a risk weight of zero and do not require any equity

[17] The latter, however, would alter households' savings behavior and make deposits sensitive to sovereign risk.

holdings. Their asset allocation is subject to the regulatory constraint

$$L \leq \mu E, \tag{4.28}$$

where μ denotes the equity multiplier.[18] Given a minimum capital requirement of 8% as in Basel II, for example, a bank's loan volume must not be larger than 12.5 times its equity. Consequently, the bank chooses deposits and asset allocation in order to maximize expected profits

$$\max_{L,D} \int_{A^*}^{\bar{A}} ALdF(A) + [1 - \max\{F(A^*), p\}]R(D + E - L) - [1 - F(A^*)]D \tag{4.29}$$

subject to the regulatory constraint (4.28). Using a similar logic as in the baseline model, one can derive the corresponding failure threshold A^* based on its general definition (4.3): As long as sovereign bonds are repaid, they provide a buffer to absorb loan losses. The bank's failure threshold therefore increases in loans and is at most $\frac{D-R(D+E-\mu E)}{\mu E}$. The latter represents the case in which the bank provides the maximum amount of loans possible, i.e. if $L = \mu E$. This scenario is captured by the lower, upward-sloping curve in figure 4.8. If they are not repaid, however, holding bonds immediately reduces a bank's capacity to absorb loan losses. The failure threshold then decreases in loans, which at the margin yield A^* while bonds yield zero. It is at least $\frac{D}{\mu E}$ such that the bank is most stable if it provides the maximum amount of loans, $L = \mu E$, and holds as few bonds as possible. The upper, downward-sloping curve in figure 4.8 illustrates this case. Consequently, if bonds are repaid if the bank fails (i.e. if $\widetilde{R} = R$ at $A = A^*$), the government is necessarily more robust than the least stable bank such that $F^{-1}(p) < \frac{D-R(D+E-\mu E)}{\mu E}$ or, equivalently, $p < F\left(\frac{D-R(D+E-\mu E)}{\mu E}\right) \equiv p_1$. Otherwise, it would default at $A = A^*$ and sovereign bonds would not be repaid. Similarly, if bonds are not repaid when the bank fails (i.e. if $\widetilde{R} = 0$ at $A = A^*$), the government is necessarily less robust than the most stable bank such that $F^{-1}(p) > \frac{D}{\mu E}$ or, equivalently, $p > F\left(\frac{D}{\mu E}\right) \equiv p_2$. In contrast to the baseline model, the cutoffs p_1 and p_2 differ because capital requirements prevent an all-loan bank. If sovereign risk is in this interim region, i.e. if $p \in [p_1, p_2]$, the bank survives in case the government repays its bonds but fails otherwise. Consequently, the sovereign default is the very reason for bank failure and both thresholds coincide, i.e. $A^* = F^{-1}(p)$.

One can summarize the bank's failure threshold as a function of sovereign risk for these three cases:

$$A^* = \begin{cases} \max\left\{\frac{D-R(D+E-L)}{L}, F^{-1}(p)\right\}, & \text{if } p < p_1 \\ F^{-1}(p), & \text{if } p \in [p_1, p_2] \\ \min\left\{\frac{D}{L}, F^{-1}(p)\right\}, & \text{if } p > p_2 \end{cases} \tag{4.30}$$

[18] If the capital requirement is k, the multiplier equals $\mu = 1/k$.

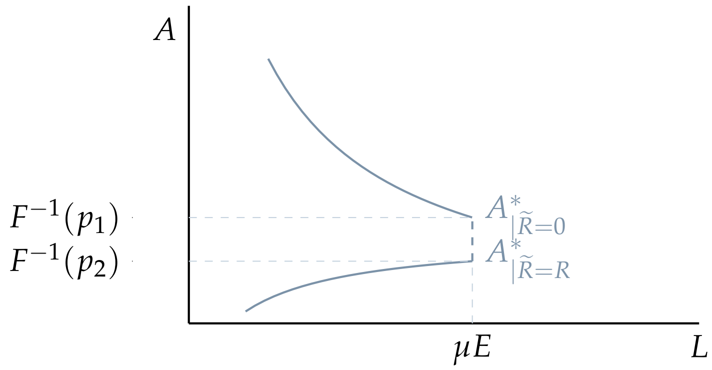

FIGURE 4.8: Bank's failure threshold

We solve for the bank's optimal asset allocation using the default threshold in (4.30). As in the unconstrained baseline model, the bank's optimization problem is convex or linear in L and D such that a corner solution emerges. As a result, the bank's demand for deposits D is indeterminate and perfectly elastic at the risk-free interest rate; it accepts any amount of deposits supplied by households D. Regarding the asset allocation, the bank chooses between two options: It either provides as much loans as possible and invests the remainder in sovereign bonds, i.e. $L = \mu E$ and $G = D + E - \mu E$; or it only purchases sovereign bonds, i.e. $L = 0$ and $G = D + E$. As in the baseline model, the bank chooses the former if this allocation promises higher expected profits, i.e. if $\pi(\mu E) \geq \pi(0)$. The results are summarized as follows:

Lemma 3. *The bank's deposit demand, D, is perfectly elastic. Define the cutoff:*

$$R' = \begin{cases} \frac{1}{1-p}\left[E(A) + \int_0^{\frac{D-R(D+E-\mu E)}{\mu E}} F(A)dA - \frac{p[D-R(D+E-\mu E)]}{\mu E}\right], & \text{if } p < p_1 \\ \frac{1}{1-p}\left[E(A) + \int_0^{F^{-1}(p)} F(A)dA - pF^{-1}(p)\right], & \text{if } p \in [p_1, p_2] \\ \frac{1}{1-p}\left[E(A) + \int_0^{\frac{D}{\mu E}} F(A)dA - \frac{pD}{\mu E}\right], & \text{if } p > p_2 \end{cases} \tag{4.31}$$

R' decreases in the capital requirement if $p < p_1$, is unchanged if $p \in [p_1, p_2]$, and increases if $p > p_2$. The bank's loan volume equals

$$L = \begin{cases} \mu E, & \text{if } R \leq R' \\ 0, & \text{if } R > R' \end{cases} \tag{4.32}$$

and its sovereign bond holdings are $G = D + E - L$. The bank's failure threshold is either

$$A^* = \begin{cases} \frac{D-R(D+E-\mu E)}{\mu E}, & \text{if } p < p_1 \\ F^{-1}(p), & \text{if } p \in [p_1, p_2] \\ \frac{D}{\mu E}, & \text{if } p > p_2 \end{cases} \tag{4.33}$$

if $R \leq R'$ or $A^* = F^{-1}(p)$ if $R > R'$.

Proof: See Appendix 4.B.

The bank's portfolio consists of both loans and sovereign bonds as long as the bond return is moderate, i.e. as long as it is small enough such that expected bank profits from investing in a combined portfolio of loans and bonds are higher than in case of a bonds-only portfolio. Note that – although defined in a piecewise manner – the cutoff return R' exhibits no discrete jumps and is increasing in p. Tighter regulation (i.e., μ is smaller) induces the bank to favor the relatively safer portfolio type.

4.5.2 Equilibrium

The choices of the households and the government are similar to those in the baseline model discussed in sections 4.3.2 and 4.3.3, respectively. Combining these results with lemma 3 establishes:

Proposition 3. *The equilibrium allocation $\{A^*, \hat{A}, D, G, L, p, R, R'\}$ is characterized by conditions (4.2), (4.10) - (4.12), (4.20), and (4.31) - (4.33). Using (4.20), define the sovereign default threshold for $L = \mu E$:*

$$\hat{A}_{|L=\mu E} = \begin{cases} \frac{D-R(D+E-\mu E)}{\mu E} + \max\left\{\frac{BR-\bar{\tau}(D+W_2)}{\mu E}, \frac{BR-\bar{\tau}(D+W_2)}{\bar{\tau}\mu E}\right\}, & \text{if } R \leq R_2 \\ \bar{A}, & \text{if } R > R_2 \end{cases} \tag{4.34}$$

R_2 equals $\frac{\bar{\tau}(W_2+\bar{A}\mu E)}{(1-\omega\bar{\tau})B}$. Two types of equilibria may exist:

- *The 'good' equilibrium with $p_g < 1$ and $R_g < R_2$ exists if $\exists R \in [1, R_2)$ such that $F[\hat{A}_{|L=D+E}(R)] < 1 - \frac{1}{R}$.*
- *The 'bad' equilibrium with $p_b = 1$ and $R \to \infty$ always exists.*

In each type of equilibrium, banks hold a combination of loans and sovereign bonds: They provide the maximum amount of loans $L = \mu E$ and invest the remainder in sovereign bonds, $G = D + E - \mu E$. The bank failure threshold is

$$A^* = \begin{cases} \frac{D-R(D+E-\mu E)}{\mu E}, & \text{if } R \leq R_0 \\ \min\left\{\frac{D-R(D+E-\mu E)}{\mu E} + \frac{BR-\bar{\tau}(D+W_2)}{\bar{\tau}\mu E}, \frac{D}{\mu E}\right\}, & \text{if } R > R_0 \end{cases}$$

and the government's default threshold equals $\hat{A} = \hat{A}_{|L=\mu E}$.

Proof: See Appendix 4.B.

The preferential treatment of sovereign bonds, which are subject to zero risk weights and require no equity, is one reason why banks now invest in fairly priced sovereign bonds. Recall that in the baseline model they do not purchase any bonds at all because fair pricing makes them less attractive than loans. Consequently, banks become sensitive to sovereign risk through bond return and repayment and a scenario with adverse feedback loops is possible.

4.5.3 Comparative statics

As in the baseline model, three cases with fundamentally different channels of bank-sovereign contagion are possible: First, the banks are less stable than the government (i.e., $A^* > \hat{A}$), which is the case if the bond return is low. Bank-sovereign contagion may thus occur because of government guarantees. Second, banks are at least as stable than the government (i.e., $A^* < \hat{A}$), which is the case if the bond return exceeds the cutoff R_0. This means that the tax capacity is small compared to the level of public debt such that quite a large taxable income from bank shareholders (i.e., a high realization of A) is necessary to raise sufficient revenue. In reality, this describes highly indebted countries with a small tax base. Hence, contagion occurs even without bank failure in the first place simply due to a small dividend payout to bank shareholders that leads to an erosion of the tax base. Third, an adverse feedback is possible in the latter scenario as the bank may fail because sovereign bonds are not repaid.

4.5.3.1 Sovereign risk

The sovereign default threshold is given by (4.34), which means that the default probability $p = F(\hat{A})$ and the bond return R react to changes of the fiscal and regulatory environment as follows:

Corollary 3. *In the 'good' equilibrium, the sovereign default probability satisfies* $\frac{\partial p}{\partial \bar{\tau}} < 0$ *and* $\frac{\partial p}{\partial B} > 0$, *which implies* $\frac{\partial R}{\partial \bar{\tau}} < 0$ *and* $\frac{\partial R}{\partial B} > 0$. *The sensitivities of* p *and* R *to the regulatory multiplier* μ *are positive as long as* $R \leq R_0$ *but can be of either sign for* $R > R_0$.

Proof: See Appendix 4.B.

A fiscally sound country characterized by low public debt and a high tax capacity generally features a reduced probability of sovereign default, which translates into relatively small bond returns. A more fragile country, however, is more likely to default and thus borrows at higher interest rates.

The impact of capital requirements on sovereign risk is more subtle: If a government is less likely to default than banks (i.e., if $\hat{A} \leq A^*$ or, equivalently, $R \leq R_0$), tighter capital requirements reduce sovereign risk, as banks are less exposed to loan risk and absorb a larger amount of potential losses. This, in turn, lowers the cost of deposit insurance that might ultimately trigger its own default. Hence, tighter capital regulation clearly improves fiscal stability. If the government is more vulnerable in equilibrium (i.e., if $\hat{A} > A^*$ or, equivalently, $R > R_0$), however, this effect can be ambiguous. Recall that a sovereign default occurs in this case because the tax base is so small that the government cannot raise sufficient tax revenue. The impact of regulation on bank profits is therefore critical: Tighter capital requirements effectively force banks to reallocate assets from loans to sovereign bonds. This may increase the realized bank profit as long as the return of bonds exceeds that of loans at the sovereign default threshold (i.e., as long as $R > \hat{A}$) such that tighter regulation, due to its impact on taxable date 2 income, still reduces sovereign risk. If the sovereign default threshold $\hat{A}$ is very high, however, bank profits and the tax base increase if banks are allowed to hold more loans. These still perform very well at the default threshold and yield a larger (taxable) payoff than sovereign bonds (i.e., $\hat{A} > R$). This is the reason why a tighter regulatory stance might even weaken fiscal stability in these countries characterized by high sovereign risk and high interest rates in equilibrium. Note that for capital regulation to increase sovereign risk, the default threshold and the bond return need to be very high, which is a rather unlikely scenario for the 'good' equilibrium, however.[19] Under such circumstances, it appears more likely that the 'good' equilibrium ceases to exist such that only the 'bad' equilibrium prevails. Apart from this special case, tighter capital requirements reduce sovereign risk. This also implies that the government is more stable and benefits from lower interest rates in an allocation where banks hold both loans and sovereign bonds than in the unconstrained equilibrium summarized in proposition 1.

4.5.3.2 Bank risk

Bank's sovereign bond holdings link bank and sovereign risks through bond returns and repayment, which creates the possibility of an adverse feedback. Recall that the failure threshold of banks considerably varies depending on the equilibrium bond return[20]

$$A^* = \begin{cases} \frac{D-R(D+E-\mu E)}{\mu E}, & \text{if } R \leq R_0 \\ \frac{D-R(D+E-\mu E)}{\mu E} + \frac{BR-\bar{\tau}(D+W_2)}{\bar{\tau}\mu E}, & \text{if } R \in (R_0, R_1) \\ \frac{D}{\mu E}, & \text{if } R \geq R_1 \end{cases} \tag{4.35}$$

where the cutoffs R_0 and R_1 follow from (4.18) and (4.19). Recall figure 4.4: As long as the equilibrium bond return is small ($R \leq R_0$) such that the government is more stable than banks, bonds provide a cushion to absorb loan losses. If, however, the bond return is large ($R \geq R_1$) due to a substantial debt burden, in which case the

19 In addition, it is only feasible if the maximum loan return $\bar{A}$ is sufficiently large, i.e., $\bar{A} > \frac{\bar{\tau}W_2}{B-\bar{\tau}(D+E)}$ or, equivalently, $R_2 > \frac{\bar{\tau}W_2}{B-\bar{\tau}(D+E)}$.

20 A summary of these cases can be found in appendix 4.C.

government is less stable than the bank, bond holdings directly translate into losses at the bank failure threshold A^*; this uses up equity and weakens banks' resilience. In an intermediate case $R \in (R_0, R_1)$, the bank's failure is conditional upon non-repayment of bonds: It would survive for an even worse loan performance if bonds were repaid but it cannot absorb losses on both assets. As a result, the sovereign default is the very reason for bank failure and both thresholds (A^* and $\hat{A}$) just coincide. This case reflects the negative feedback loop as a poor loan performance itself does not push banks into bankruptcy but triggers a sovereign default, which immediately leads to bank failure. Using the bond return's sensitivities from corollary 3, differentiating (4.35) yields:

Corollary 4. *The sensitivities of bank risk, $F(A^*)$, differ between three cases:*

- *If $R \leq R_0$, bank risk increases in the tax capacity, $\frac{\partial A^*}{\partial \bar{\tau}} > 0$, and decreases in public debt, $\frac{\partial A^*}{\partial B} < 0$, whereas capital requirements have an ambiguous effect, $\frac{\partial A^*}{\partial \mu}$.*
- *If $R \in (R_0, R_1)$, bank risk decreases in the tax capacity, $\frac{\partial A^*}{\partial \bar{\tau}} < 0$, and increases in public debt, $\frac{\partial A^*}{\partial B} > 0$, whereas the effect of capital requirements can be of either sign, $\frac{\partial A^*}{\partial \mu}$.*
- *If $R \geq R_1$, bank risk does not directly depend on fiscal fundamentals, $\frac{\partial A^*}{\partial \bar{\tau}} = \frac{\partial A^*}{\partial B} = 0$, and decreases in the regulatory multiplier $\frac{\partial A^*}{\partial \mu} < 0$.*

Proof: See Appendix 4.B.

Bank risk exhibits significant differences depending on the equilibrium bond return. In the first case, i.e. $R \leq R_0$, bonds are always repaid as long as the bank survives. Hence, they reduce banks' exposure to loan risk and generate profits that may serve as a buffer to absorb loan losses. The bond return plays a prominent role as it reduces bank risk by generating higher profits and links it to fiscal fundamentals. Since a higher public debt level, B, and a lower tax capacity, $\bar{\tau}$, raise the bond return as shown in corollary 3, they even enhance banks' resilience. Therefore, slightly increasing sovereign risk in a country that is still fiscally sound (i.e., pays a relatively low bond return in equilibrium) may reduce bank risk because higher bond returns raise profits and (final-period) equity. The impact of the regulatory multiplier μ is, in principle, ambiguous in such a scenario because of two countervailing effects: On the one hand, tighter regulation directly lowers the bank's exposure to risky loans thereby making it more resilient. On the other hand, it reduces sovereign risk as shown in corollary 3 such that bond returns fall; the latter, in turn, reduces bank profits and thus its capacity to withstand a poor loan performance. However, it is likely that the positive direct effect prevails. The effects associated with the bond return are of course expected to be less pronounced in reality where banks hold diversified portfolios of sovereign bonds and may, in fact, substitute foreign for domestic bonds if the latter become riskier. However, banks' sovereign exposures are also characterized by a significant home bias that is empirically well-documented.

In the second case, i.e. $R \in (R_0, R_1)$, a bank failure is triggered by the non-repayment of government bonds such that sovereign and bank risk are similar and their default thresholds coincide. In other words, banks fail because of an adverse feedback. As a result, increases of sovereign risk imply higher bank risk. Weaker fiscal fundamentals (B and $\bar{\tau}$), therefore, increase bank risk, whereas tighter capital regulation is generally ambiguous but likely positive as discussed in section 4.5.3.1.

In the third case, i.e. $R \geq R_1$, banks are more stable than the government, and do not immediately fail if bonds are not repaid. Put differently, sovereign risk is so high that the government defaults even though bank loans perform rather well. This case also captures bank risk in the 'bad' equilibrium, in which the country experiences a sovereign debt crisis and defaults irrespective of the banking sector's loan performance. Bank risk then only depends on bank characteristics and is disconnected from fiscal fundamentals in the sense that they have no direct impact on failure threshold and probability. Although there is no scope for any immediate feedback like in the second case, the sovereign default weakens banks' resilience. Hence, they become more vulnerable than in the case in which bonds are repaid. Interestingly, relaxing capital requirements (i.e. raising the regulatory multiplier) reduces bank risk in this scenario: The intuition is that banks then hold more loans, which are still worth A^* at the threshold, and fewer sovereign bonds, which are then worth zero.

The interaction between bank and sovereign risks is a key feature of this model. In fiscally sound countries that only need to pay a low bond return, there is a tension between bank and sovereign risks because holding bonds only yields small profits due to low returns such that banks' loss-absorbing capacity is limited. This means that bank risk is *ceteris paribus* higher in a risk-free country ($R = 1$) than in a still solid country with a positive default probability (i.e., if R is close to R_0). As soon as sovereign risk and the corresponding bond return increase above a cutoff, the relation between bank and sovereign risks is reversed because bank failure crucially depends on bond repayment. Improving fiscal fundamentals then makes bond repayment more and a bank failure less likely. If bond return and debt burden are so large that a sovereign default occurs even though bank loans perform relatively well, for instance, in a 'bad' equilibrium, the bank can absorb the bond losses and its own risk only depends on leverage and loan performance. Hence, bank risk does not directly depend on fiscal fundamentals but is increased by a sovereign default.

4.6 Conclusion

We present a model of the bank-sovereign nexus, which has been a prominent feature in the ongoing European banking and debt crisis. In order to investigate contagion between banks and sovereigns and to analyze the impact of government guarantees for stability and social welfare, the model uniquely combines financial instability with sovereign debt fragility in the form of multiple equilibria and self-fulfilling debt crises. Unlike in most other papers on that topic, risks originate in the banking sector, more precisely, from the banks' asset side. A bad realization of the stochastic loan return directly hits the bank but may indirectly cause a sovereign default. This is because the fate of the two is tied together by deposit insurance cost and taxation. Importantly, the provision of deposit insurance can either trigger or prevent a sovereign default. The outcome depends crucially on the liquidation value of the bank's assets: A government safeguards its own stability whenever its intervention prevents high cost of a disorderly bank liquidation but may jeopardize it otherwise. The provision of deposit insurance additionally lifts domestic consumption levels as well as welfare as it avoids significant bankruptcy cost and may effectively shift the public debt burden onto foreign bondholders. This is a key difference to other contributions on sovereign debt, in which default is the result of a conscious, strategic decision.

Banks in our model only invest into fairly priced bonds due to their preferential regulatory treatment, i.e. because no equity has to be held against them. These holdings make them sensitive to the fiscal state and causes the unhealthy symbiosis between the banking sector and the sovereign. Situations may therefore arise, in which the bank only fails because of sovereign default. Adverse feedback loops of that sort were the source of major problems in recent years. The model is therefore able to rationalize both the Irish case, in which banks stood at the heart of the problem, and, to some extent, the Greek scenario, in which a sudden loss of confidence into the government was the decisive trigger. The interplay between the risks of banks and sovereigns reveals a number of interesting interdependencies. We find, for instance, that financial and fiscal stability may not always work in the same direction in the sense that higher bond returns, which are the result of weaker fiscal fundamentals, provide a buffer to absorb loan losses to the bank and thus stabilize the latter. While this is true, however, for relatively safe countries, the effect reverses if the bank is located in unstable jurisdictions. Stricter capital requirements tend to enhance the resilience of both banks and sovereigns, but also raise awareness of potentially countervailing effects. The novel findings of this analysis clarify the fundamental mechanisms of contagion between governments and banks and outline possible consequences of the policy options at hand. They also rationalize important implications of deposit insurance, potential welfare benefits of sovereign default, as well as consequences of preferential treatments for sovereign bond holdings and tighter capital requirements.

Bank-sovereign contagion and adverse feedback effects are at the core of our analysis. Motivated by recent crises in Ireland and Spain, the focus of our paper is clearly on risks originating in the banking sector. In further research, one could also include other sources of risk (e.g. political or macroeconomic shocks) to study sovereign-bank contagion in more detail. Moreover, our analysis provides an explanation for why banks hold fairly priced domestic sovereign bonds; namely, that they receive preferential treatment in the current regulatory framework. Further motivations for bond holdings, such as their role as a collateral in the interbank market, and their effect on the relation between bank stability and sovereign risks may be explored as well. Our paper focuses on studying systemic crises (i.e. correlated returns), the consequences of which can be particularly disastrous. An extension, however, could analyze which mechanisms of the interplay between bank and sovereign risks prevail in case of imperfect correlation and how deposit insurance schemes would affect welfare in such an environment.

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Appendix

4.A List of notations

Variables	
A^*	Bank's failure threshold
$\hat{A}$	Sovereign default threshold
C_t	Household consumption at date t
D	Deposits
L	Loans
G	Bank's sovereign bond holdings
p	Sovereign default probability
R	Sovereign bond return
t	Consumption tax rate
τ	Equivalent income tax rate, $\tau = \frac{t}{1+t}$
Parameters	
$\overline{A}$	Maximum loan return
B	Public debt, sovereign bonds
E	Bank equity
v	Liquidation value of bank loans
W_t	Households' labor income (date t)
μ	Regulatory equity multiplier
$\bar{\tau}$	Maximum feasible tax rate
Definitions and Functions	
V_2	Domestic welfare (date 2)
ω	Share of domestically held sovereign bonds
$F(A)$	Distribution function of loan returns

Table 4.1: List of notations

4.B Proofs and derivations

Proof of Lemma 1: We distinguish between two cases: Suppose first $p \leq F\left(\frac{D}{D+E}\right)$ such that bonds are repaid for the realization of A at which the bank fails and $\max\{F(A^*), p\} = F(A^*)$. Integrating the term $\int_{A^*}^{\bar{A}} dF(A)$ yields the expected bank profit:

$$\pi = \left[\bar{A} - F(A^*)A^* - \int_{A^*}^{\bar{A}} F(A)dA\right] L + [1 - F(A^*)][R(D+E-L) - D]$$

where by (4.5), its failure threshold is $A^* = \max\left\{\frac{D-R(D+E-L)}{L}, F^{-1}(p)\right\}$.[21] The first-order condition w.r.t. D is nonnegative due to $R \geq 1$:

$$\frac{\partial \pi}{\partial D} = [1 - F(A^*)](R-1) \geq 0$$

Hence, the bank always raises the maximum amount of deposits households are willing to supply at the risk-free interest rate (normalized to one). The first-order condition w.r.t. L is

$$\frac{\partial \pi}{\partial L} = \bar{A} - F(A^*)A^* - \int_{A^*}^{\bar{A}} F(A)dA - [1 - F(A^*)]R$$

The objective function is linear or convex in L as the second-order condition is nonnegative

$$\frac{\partial^2 \pi}{\partial L^2} = f(A^*)(R - A^*)\frac{\partial A^*}{\partial L} \geq 0$$

because of $\frac{\partial A^*}{\partial L} = \frac{R(D+E)-D}{L^2} > 0$ if $A^* > F^{-1}(p)$ and $\frac{\partial A^*}{\partial L} = 0$ if $A^* = F^{-1}(p)$.[22] Note that (4.5) implies $R \geq A^*$. Therefore, the optimal choice is determined by a corner solution as expected profits are maximized either if $L = D + E$ or $L = 0$. The bank chooses $L = D + E$ and $G = 0$ if $\pi(D+E) \geq \pi(0)$:

$$\left[\bar{A} - \frac{\bar{p}D}{D+E} - \int_{D/(D+E)}^{\bar{A}} F(A)dA\right](D+E) - (1-\bar{p})D \geq (1-p)[R(D+E) - D]$$

which uses $A^* = \frac{D}{D+E}$ if $L = D + E$ and $A^* = F^{-1}(p)$ if $L = 0$. Otherwise, the bank purchases sovereign bonds only ($L = 0$ and $G = D + E$). Rearranging yields

$$\underbrace{\bar{A} - \int_{D/(D+E)}^{\bar{A}} F(A)dA}_{E(A)+\int_0^{D/(D+E)} F(A)dA} \geq (1-p)R + \frac{pD}{D+E} \tag{4.36}$$

which implies the maximum bond return for bank lending R'.

Second, suppose instead that $p > F\left(\frac{D}{D+E}\right)$. Bonds are then not repaid for the realization of A at which the bank fails and $\max\{F(A^*), p\} = p$. Hence, the bank's expected

21 More precisely, the threshold is $[D - R(D+E-L)]/L$ if $L \geq [R(D+E) - D]/[R - F^{-1}(p)]$ and $F^{-1}(p)$ else.

22 Note that the objective function π is linear for $L < [R(D+E) - D]/[R - F^{-1}(p)]$ and convex for larger L; there is no discrete jump of π at $L = [R(D+E) - D]/[R - F^{-1}(p)]$.

profit is

$$\pi = \left[\bar{A} - F(A^*)A^* - \int_{A^*}^{\bar{A}} F(A)dA\right] L + (1-p)R(D+E-L) - [1-F(A^*)]D$$

where by (4.5), its default threshold equals $A^* = \min\left\{\frac{D}{L}, F^{-1}(p)\right\}$.[23] The first-order condition w.r.t. D is

$$\frac{\partial \pi}{\partial D} = (1-p)R - [1-F(A^*)]$$

In equilibrium, bonds are priced such that this condition is nonnegative and the bank raises the maximum amount of deposits supplied by households. The first-order condition w.r.t. L is

$$\frac{\partial \pi}{\partial L} = \bar{A} - F(A^*)A^* - \int_{A^*}^{\bar{A}} F(A)dA - (1-p)R$$

The objective function is linear or convex in L as the second-order condition is again nonnegative

$$\frac{\partial^2 \pi}{\partial L^2} = -f(A^*)A^* \frac{\partial A^*}{\partial L} \geq 0$$

because of $\frac{\partial A^*}{\partial L} = -\frac{D}{L^2} < 0$ if $A^* > F^{-1}(p)$ and $\frac{\partial A^*}{\partial L} = 0$ if $A^* = F^{-1}(p)$.[24] The bank chooses $L = D + E$ and $G = 0$ if $\pi(D+E) \geq \pi(0)$:

$$\left[\bar{A} - \frac{\bar{p}D}{D+E} - \int_{D/(D+E)}^{\bar{A}} F(A)dA\right](D+E) - (1-\bar{p})D \geq (1-p)[R(D+E) - D]$$

Rearranging yields the cutoff R' as in (4.36). Finally, one obtains the sensitivity of R' by totally differentiating (4.36):

$$\frac{\partial R'}{\partial E} = \frac{D}{(D+E)^2}\frac{p-\bar{p}}{1-p}$$

such that $\frac{\partial R'}{\partial E} < 0$ if $p < \bar{p}$ and $\frac{\partial R'}{\partial E} > 0$ if $p > \bar{p}$. *Q.E.D.*

Proof of Proposition 1: The 'bad' equilibrium always exists, as for $R \to \infty$, $\hat{A} = \bar{A}$, and $p = 1$. The bond return is determined by (4.11) which means that a default with certainty implies that $R \to \infty$ is indeed justified. Since $R' \to \infty$, the bank prefers holding loans only, $L = D + E$. To prove the existence of the 'good' equilibrium, we proceed in two steps: First, suppose $L = D + E$ such that $\hat{A} = \hat{A}_{|L=D+E}$. Given that a

23 More precisely, the default threshold is D/L if $L \geq D/F^{-1}(p)$ and $F^{-1}(p)$ else.

24 Note that the objective function is linear for $L < D/F^{-1}(p)$ and convex for larger L; there is no discrete jump of π at $L = D/F^{-1}(p)$.

bond return $R \in [1, R_2)$ with $F[\hat{A}_{|L=D+E}(R^*)] \leq 1 - \frac{1}{R}$ exists, the continuity[25] of both $F(A)$ and $\hat{A}_{|L=D+E}$, which implies that $F[\hat{A}_{|L=D+E}(R)]$ is non-decreasing in R, together with $F[\hat{A}_{|L=D+E}(1)] \geq 0 = 1 - \frac{1}{1}$ ensure the existence of the 'good' equilibrium with $R_g \leq R$. Graphically, bond pricing and default curve intersect. Hence, one can identify an equilibrium candidate; for it to be a true equilibrium, one needs to show that $R_g \leq R'$ is satisfied such that the bank is indeed willing to hold loans only: Substituting $R_g = \frac{1}{1-p}$ from the bond pricing condition into (4.6) implies:

$$p \leq \frac{D+E}{D}\left[E(A) + \int_0^{\frac{D}{D+E}} F(A)dA - 1\right] \tag{4.37}$$

This means that the default probability implied by R_g, $p_g = F[\hat{A}_{|L=D+E}(R_g)]$, needs to satisfy the above condition. If condition (4.37) is violated for all potential values of R^*, implying that the bank would prefer to hold sovereign bonds only, the candidate identified above is no equilibrium. Therefore, only the 'bad' equilibrium exists in this case. In general, a bank holding sovereign bonds only cannot be an equilibrium outcome: The government's default probability is then either zero or one and, by (4.11), the bond return is either one or infinity. These values, in turn, are smaller than the cutoff R'; the bank would then prefer loans over bonds.

Since $L = D + E$ in each type of equilibrium, $A^* = \frac{D}{D+E}$ and $\hat{A} = \hat{A}_{|L=D+E}$ immediately follow. *Q.E.D*

Proof of Corollary 1: The systems (4.11) and (4.21) jointly determine $\hat{A}$ and R. Since $R < R'$ in the 'good' equilibrium, the system is

$$J^1 = \hat{A} - \frac{D}{D+E} - \max\left\{\frac{BR - \tau(D+W_2)}{D+E}, \frac{BR - \tau(D+W_2)}{\bar{\tau}(D+E)}\right\} = 0$$
$$J^2 = [1 - F(\hat{A})]R - 1 = 0$$

Provided that in equilibrium $R \leq R_0$, the Jacobian matrix is

$$J = \begin{bmatrix} 1 & -\frac{B}{D+E} \\ -f(\hat{A})R & 1 - F(\hat{A}) \end{bmatrix}$$

The Jacobian determinant is

$$|J| = 1 - F(\hat{A}) - \frac{f(\hat{A})BR}{D+E} > 0 \tag{4.38}$$

The sign of the Jacobian determinant is derived using a specific property of the

25 Note that $\hat{A}_{|L=D+E}(R)$ has two kinks at $R = R_0$ and $R = R_2$ but no jumps.

equilibrium, which follows from the intersection of the default threshold and the bond pricing equation: In the 'good' equilibrium, the bond pricing curve is steeper than the default threshold (i.e., $1/R^2 > f(\hat{A})d\hat{A}/dR$). This property is necessary for the existence of the equilibrium since, for $R = 1$, $F[\hat{A}(1)] \geq 0 = p(1)$.[26] From substituting $1 - F(\hat{A}) = 1/R$, which holds in equilibrium, into (4.38), it follows that $|J| > 0$ in the 'good' equilibrium. Applying Cramer's rule yields:

$$\frac{\partial R}{\partial B} = \frac{\frac{f(\hat{A})R^2}{D+E}}{|J|} > 0$$

$$\frac{\partial R}{\partial \bar{\tau}} = -\frac{\frac{f(\hat{A})(D+W_2)R}{D+E}}{|J|} < 0$$

$$\frac{\partial R}{\partial E} = -\frac{\frac{f(\hat{A})R(BR-\bar{\tau}W_2+(1-\bar{\tau})D)}{(D+E)^2}}{|J|} < 0$$

$$\frac{\partial \hat{A}}{\partial B} = \frac{\frac{(1-F(\hat{A}))R}{D+E}}{|J|} > 0$$

$$\frac{\partial \hat{A}}{\partial \bar{\tau}} = -\frac{\frac{(1-F(\hat{A}))(D+W_2)}{D+E}}{|J|} < 0$$

$$\frac{\partial \hat{A}}{\partial E} = -\frac{\frac{(1-F(\hat{A}))(BR-\bar{\tau}W_2+(1-\bar{\tau})D)}{(D+E)^2}}{|J|} < 0$$

If in equilibrium $R > R_0$, the Jacobian matrix is

$$J = \begin{bmatrix} 1 & -\frac{B}{\bar{\tau}(D+E)} \\ -f(\hat{A})R & 1 - F(\hat{A}) \end{bmatrix}$$

The Jacobian determinant is

$$|J| = 1 - F(\hat{A}) - \frac{f(\hat{A})BR}{\bar{\tau}(D+E)} > 0$$

The sign of $|J|$ is derived using the same approach as above; thus, the signs of the sensitivities do not differ from the case $R \leq R_0$. Applying Cramer's rule yields:

$$\frac{\partial R}{\partial B} = \frac{\frac{f(\hat{A})R^2}{\bar{\tau}(D+E)}}{|J|} > 0$$

$$\frac{\partial R}{\partial \bar{\tau}} = -\frac{\frac{f(\hat{A})(D+W_2)R}{\bar{\tau}(D+E)}}{|J|} < 0$$

[26] For a graphical exposition, refer to figure 4.5.

$$\frac{\partial R}{\partial E} = -\frac{\frac{f(\hat{A})R(BR-\bar{\tau}W_2+(1-\bar{\tau})D)}{\bar{\tau}(D+E)^2}}{|J|} < 0$$

$$\frac{\partial \hat{A}}{\partial B} = \frac{\frac{(1-F(\hat{A}))R}{\bar{\tau}(D+E)}}{|J|} > 0$$

$$\frac{\partial \hat{A}}{\partial \bar{\tau}} = -\frac{\frac{(1-F(\hat{A}))(D+W_2)}{\bar{\tau}(D+E)}}{|J|} < 0$$

$$\frac{\partial \hat{A}}{\partial E} = -\frac{\frac{(1-F(\hat{A}))(BR-\bar{\tau}W_2+(1-\bar{\tau})D)}{\bar{\tau}(D+E)^2}}{|J|} < 0$$

The signs of the sensitivities in corollary 1 then follow from $p = F(\hat{A})$. *Q.E.D.*

Proof of Proposition 2: Given (4.24), one needs to distinguish between three intervals of the equilibrium bond return R: First, if $R \geq R_0$, the default thresholds $\hat{A}$ and $\hat{A}_N$ coincide such that $p = p_N$ irrespective of v. Second, if $R \in [R_0 - \frac{(1-v)\bar{\tau}D}{B}, R_0)$, $\hat{A}_N = \frac{D}{D+E} = A^*$ whereas $\hat{A} < A^*$ for all $R < R_0$, which implies that $\hat{A}_N > \hat{A}$ and $p_N > p$. Consequently, $\hat{A}_N \geq \hat{A}$ for all $R \geq R_0 - \frac{(1-v)\bar{\tau}D}{B}$. Rearranging this condition yields

$$v \leq \frac{BR - \bar{\tau}W_2}{\bar{\tau}D} \tag{4.39}$$

Third, if $R < R_0 - \frac{(1-v)\bar{\tau}D}{B}$, $\hat{A}_N = \frac{BR-\bar{\tau}W_2}{v\bar{\tau}(D+E)}$ and $\hat{A} = \frac{D}{D+E} + \frac{BR-\bar{\tau}(D+W_2)}{D+E}$. Solving $\hat{A}_N \geq \hat{A}$ for v yields

$$v \leq \frac{BR - \bar{\tau}W_2}{\bar{\tau}[BR - \bar{\tau}W_2 + (1-\bar{\tau})D]} \tag{4.40}$$

For $p \geq p_N$, the equilibrium allocation (i.e., the combination of R and v) needs to satisfy either (4.39) or (4.40). Since all combinations that fulfil (4.40) are also consistent with (4.35) and since $v \leq 1$, condition (4.25) characterizes all allocations for which deposit insurance does not increase the government's default threshold and vulnerability. *Q.E.D.*

Proof of Lemma 3: This proof is similar to the proof of lemma 1: First, it is shown that the bank's objective function is increasing in or independent of D and either linear or convex in L such that the bank is willing to accept any amount of deposits and its optimal asset allocation is a corner solution (i.e., the bank either provides no loans at all or the maximum amount possible μE). Second, we characterize the asset allocation depending on sovereign bond characteristics (i.e., p and R) by comparing expected profits for the two corner solutions. First, suppose $p < p_1$, that is, the government is still solvent for the realization of A at which the bank fails. The bank's expected profit is:

$$\pi = \left[\bar{A} - F(A^*)A^* - \int_{A^*}^{\bar{A}} F(A)dA\right] L + [1 - F(A^*)][R(D+E-L) - D]$$

where by (4.31), its default threshold equals $A^* = \max\left\{\frac{D-R(D+E-L)}{L}, F^{-1}(p)\right\}$.[27] The first-order condition w.r.t. L is nonnegative due to $R \geq 1$:

$$\frac{\partial \pi}{\partial D} = [1 - F(A^*)](R-1) \geq 0$$

The first-order condition w.r.t. L is

$$\frac{\partial \pi}{\partial L} = \bar{A} - F(A^*)A^* - \int_{A^*}^{\bar{A}} F(A)dA - [1 - F(A^*)]R$$

The objective function is linear or convex as the second-order condition is nonnegative

$$\frac{\partial^2 \pi}{\partial L^2} = f(A^*)(R - A^*)\frac{\partial A^*}{\partial L} \geq 0$$

as $\frac{\partial A^*}{\partial L} \geq 0$ and $R \geq A^*$. Therefore, expected profit is maximized either if $L = \mu E$ or $L = 0$. The bank chooses $L = \mu E$ as long as it yields a larger expected profit, $\pi(\mu E) \geq \pi(0)$:

$$\left[\bar{A} - p_1 F^{-1}(p_1) - \int_{F^{-1}(p_1)}^{\bar{A}} F(A)dA\right] \mu E + (1-p_1)[R(D+E-\mu E) - D] \geq$$
$$(1-p)[R(D+E) - D]$$

This inequality uses $A^* = F^{-1}(p_1) = \frac{D-R(D+E-\mu E)}{\mu E}$ if $L = \mu E$ and $A^* = F^{-1}(p)$ if $L = 0$. Using these definitions and rearranging yields the first part of (4.33).

Second, suppose that $p \in [p_1, p_2]$, the expected bank profit is

$$\pi = \left[\bar{A} - pF^{-1}(p) - \int_{F^{-1}(p)}^{\bar{A}} F(A)dA\right] L + (1-p)[R(D+E-L) - D]$$

where $A^* = F^{-1}(p)$ irrespective of D and L. Obviously, the objective function is linear. While it is non-decreasing in D such that the bank accepts any amount of deposits, the asset allocation is determined by comparing the corner solutions: The bank chooses $L = \mu E$ as long as

$$\left[\bar{A} - pF^{-1}(p) - \int_{F^{-1}(p)}^{\bar{A}} F(A)dA\right] \mu E + (1-p)[R(D+E-\mu E) - D] \geq$$

27 More precisely, the default threshold is again $[D - R(D+E-L)]/L$ if $L \geq [R(D+E) - D]/[R - F^{-1}(p)]$ and $F^{-1}(p)$ else.

$$(1-p)[R(D+E)-D]$$

and $L = 0$ otherwise. Rearranging yields the second part of (4.33).

Eventually, suppose $p > p_2$. The government then defaults for the realization of A at which the bank fails. Hence, the bank's expected profit is

$$\pi = \left[\bar{A} - F(A^*)A^* - \int_{A^*}^{\bar{A}} F(A)dA\right] L + (1-p)R(D+E-L) - [1-F(A^*)]D$$

where by (4.31), its default threshold equals $A^* = \min\left\{\frac{D}{L}, F^{-1}(p)\right\}$.[28] The first-order condition w.r.t. D is

$$\frac{\partial \pi}{\partial D} = (1-p)R - [1-F(A^*)]$$

In equilibrium, bonds are priced such that this condition is nonnegative and the bank raises any amount of deposits supplied by households. The first-order condition w.r.t. L is

$$\frac{d\pi}{dL} = \bar{A} - F(A^*)A^* - \int_{A^*}^{\bar{A}} F(A)dA - (1-p)R$$

The objective function is either linear or convex in L because the second-order condition is nonnegative

$$\frac{\partial^2 \pi}{\partial L^2} = -f(A^*)A^* \frac{\partial A^*}{\partial L} \geq 0$$

as $\frac{\partial A^*}{\partial L} \leq 0$. The bank chooses $L = \mu E$ if

$$\left[\bar{A} - \frac{p_2 D}{\mu E} - \int_{D/\mu E}^{\bar{A}} F(A)dA\right] \mu E + (1-p)R(D+E-\mu E) - (1-p_2)D \geq (1-p)[R(D+E)-D]$$

This inequality uses $A^* = F^{-1}(p_2) = \frac{D}{\mu E}$ if $L = \mu E$ and $A^* = F^{-1}(p)$ if $L = 0$. Applying these definitions and rearranging yields the third part of (4.33). *Q.E.D.*

Proof of Proposition 3: In the extension, we focus on the scenario where the bond return implied by fair bond pricing (4.11) never exceeds the cutoff R' given by (4.31) such that the bank always holds $L = \mu E$ and $G = D + E - \mu E$ if bonds are fairly priced. This requires

$$E(A) + \int_0^{\frac{D}{\mu E}} F(A)dA - \frac{D}{\mu E} \geq 1 \tag{4.41}$$

If this relation is satisfied, $R \leq R'$ for all $p \in [0,1]$. Since any equilibrium requires fairly priced bonds, only the asset allocation $L = \mu E$ and $G = D + E - \mu E$ is consistent with equilibrium. The bond return is determined by (4.11). A default with certainty

[28] More precisely, the default threshold is again D/L if $L \geq D/F^{-1}(p)$ and $F^{-1}(p)$ else.

therefore implies that $R \to \infty$ is indeed justified. Since $R' \to \infty$, the bank prefers to hold a combination of loans and bonds with $L = \mu E$ and $G = D + E - \mu E$. The 'good' equilibrium exists whenever there exists a bond return $R \in (1, R_2)$ such that $F[\hat{A}_{|L=D+E}(R)] < 1 - \frac{1}{R}$: Since $F[\hat{A}_{|L=D+E}(1)] \geq 0 = 1 - \frac{1}{1}$, the continuity[29] of $F(A)$ and $\hat{A}_{|L=D+E}(R)$, which also means that $F[\hat{A}_{|L=D+E}(R)]$ is increasing in R, ensures that the 'good' equilibrium with $R_g \leq R$ exists. Note that the equilibrium asset allocation $L = \mu E$ and $G = D + E - \mu E$ is ensured by the additional condition (4.41) which means that $\hat{A} = \hat{A}_{|L=D+E}$ and that the existence of R is sufficient for the existence of the equilibrium. *Q.E.D*

Proof of Corollary 3: The system (4.11) and (4.34) jointly determines $\hat{A}$ and R. Since $R < R'$ in the 'good' equilibrium, the system is

$$J^1 = \hat{A} - \frac{D - R(D + E - \mu E)}{\mu E} - \max\left\{\frac{BR - \tau(D + W_2)}{\mu E}, \frac{BR - \tau(D + W_2)}{\bar{\tau}\mu E}\right\} = 0$$
$$J^2 = [1 - F(\hat{A})]R - 1 = 0$$

Provided that in equilibrium $R \leq R_0$, the Jacobian matrix is

$$J = \begin{bmatrix} 1 & -\frac{(1-\omega)B}{\mu E} \\ -f(\hat{A})R & 1 - F(\hat{A}) \end{bmatrix}$$

The Jacobian determinant is

$$|J| = 1 - F(\hat{A}) - \frac{f(\hat{A})(1 - \omega)BR}{\mu E} > 0 \tag{4.42}$$

The sign of the Jacobian determinant is derived using a specific property of the equilibrium, which again follows from the property of the 'good' equilibrium that the bond pricing curve is steeper than the default threshold (i.e., $1/R^2 > f(\hat{A})d\hat{A}/dR$). Substituting $1 - F(\hat{A}) = 1/R$, which holds in equilibrium, into (4.42), it follows that $|J| > 0$ in the 'good' equilibrium. Using Cramer's rule yields:

$$\frac{\partial R}{\partial B} = \frac{\frac{f(\hat{A})R^2}{\mu E}}{|J|} > 0$$
$$\frac{\partial R}{\partial \bar{\tau}} = -\frac{\frac{f(\hat{A})R(D+W_2)}{\mu E}}{|J|} < 0$$
$$\frac{\partial R}{\partial \mu} = \frac{\frac{f(\hat{A})R[R(D+E)-D-(BR-\bar{\tau}(W_2+D))]}{\mu^2 E}}{|J|} > 0$$

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[29] Note that $\hat{A}_{|L=D+E}(R)$ has two kinks at $R = R_0$ and $R = R_2$ but no jumps.

$$\frac{\partial \hat{A}}{\partial B} = \frac{\frac{(1-F(\hat{A}))R}{\mu E}}{|J|} > 0$$
$$\frac{\partial \hat{A}}{\partial \bar{\tau}} = -\frac{\frac{(1-F(\hat{A}))(D+W_2)}{\mu E}}{|J|} < 0$$
$$\frac{\partial \hat{A}}{\partial \mu} = \frac{\frac{(1-F(\hat{A}))[R(D+E)-D-(BR-\bar{\tau}(W_2+D))]}{\mu^2 E}}{|J|} > 0$$

If in equilibrium $R > R_0$, the Jacobian matrix is

$$J = \begin{bmatrix} 1 & -\frac{(1-\omega\bar{\tau})B}{\bar{\tau}\mu E} \\ -f(\hat{A})R & 1-F(\hat{A}) \end{bmatrix}$$

By the same argument as above, it can be shown that the Jacobian determinant is positive:

$$|J| = 1 - F(\hat{A}) - \frac{f(\hat{A})(1-\omega\bar{\tau})BR}{\bar{\tau}\mu E} > 0$$

Using Cramer's rule yields:

$$\frac{\partial R}{\partial B} = \frac{\frac{f(\hat{A})R^2}{\bar{\tau}\mu E}}{|J|} > 0$$
$$\frac{\partial R}{\partial \bar{\tau}} = -\frac{\frac{f(\hat{A})R(D+W_2)}{\bar{\tau}\mu E}}{|J|} < 0$$
$$\frac{\partial R}{\partial \mu} = \frac{\frac{f(\hat{A})R[\bar{\tau}W_2-R(B-\bar{\tau}(D+E))]}{\bar{\tau}\mu^2 E}}{|J|}$$
$$\frac{\partial \hat{A}}{\partial B} = \frac{\frac{(1-F(\hat{A}))R}{\bar{\tau}\mu E}}{|J|} > 0$$
$$\frac{\partial \hat{A}}{\partial \bar{\tau}} = -\frac{\frac{(1-F(\hat{A}))(D+W_2)}{\bar{\tau}\mu E}}{|J|} < 0$$
$$\frac{\partial \hat{A}}{\partial \mu} = \frac{\frac{(1-F(\hat{A}))[\bar{\tau}W_2-R(B-\bar{\tau}(D+E))]}{\bar{\tau}\mu^2 E}}{|J|}$$

The sensitivities $\frac{\partial R}{\partial \mu}$ and $\frac{\partial \hat{A}}{\partial \mu}$ are positive as long as $\bar{\tau}[R(D+E)+W_2] > BR$ or, equivalently, $R < \frac{\bar{\tau}W_2}{B-\bar{\tau}(D+E)}$.[30] Rearranging yields $\hat{A} < R$, that is, as long as the sovereign default threshold is smaller than the equilibrium bond return, sovereign risk increases in the regulatory multiplier. As soon as $\hat{A} > R$, sovereign risk decreases in the multi-

[30] Note that $R_0 < \frac{\bar{\tau}W_2}{B-\bar{\tau}(D+E)}$ such that a positive sign of these sensitivities is, in principle, feasible if the equilibrium bond return exceeds R_0.

plier. The signs of the sensitivities in corollary 3 then follow from $p = F(\hat{A})$. *Q.E.D.*

Proof of Corollary 4: If $R \leq R_0$ in equilibrium, $A^* = \frac{D-R(D+E-\mu E)}{\mu E}$. The partial derivatives are:

$$\frac{\partial A^*}{\partial B} = -\frac{D+E-\mu E}{\mu E}\frac{\partial R}{\partial B} < 0$$
$$\frac{\partial A^*}{\partial \bar{\tau}} = -\frac{D+E-\mu E}{\mu E}\frac{\partial R}{\partial \bar{\tau}} > 0$$
$$\frac{\partial A^*}{\partial \mu} = \frac{R(D+E)-D}{\mu^2 E} - \frac{D+E-\mu E}{\mu E}\frac{\partial R}{\partial \mu}$$

The signs of $\frac{\partial A^*}{\partial B}$ and $\frac{\partial A^*}{\partial \bar{\tau}}$ follow directly from the sensitivities of R summarized in corollary 3. The sign of $\frac{\partial A^*}{\partial \mu}$ is unclear given that R increases in μ. If $R \in (R_0, R_1)$, the bank and sovereign default threshold coincide such that $\frac{\partial A^*}{\partial B} > 0$ and $\frac{\partial A^*}{\partial \bar{\tau}} < 0$ and $\frac{\partial A^*}{\partial \mu}$ is ambiguous. If $R \geq R_1$, $A^* = \frac{D}{\mu E}$ is independent of the bond return, which implies that $\frac{\partial A^*}{\partial B} = \frac{\partial A^*}{\partial \bar{\tau}} = 0$ and $\frac{\partial A^*}{\partial \mu} < 0$. *Q.E.D.*

4.C Summary

	(1)	(2)	(3)
Outcome	Banks less stable than government ($A^* \geq \hat{A}$)	Banks more stable than government ($A^* \leq \hat{A}$)	Banks equally stable than government ($A^* = \hat{A}$)
Bond return	$R \leq R_0$	$R \geq R_1$	$R \in (R_0, R_1)$
Channel of bank-sovereign contagion	Dep. Insurance Cost	Taxation	Taxation
Adverse feedback	None	Sovereign default weakens banks	Sovereign default triggers bank failure
Equilibrium type	'Good'	'Good', 'bad'	'Good', 'bad'
Baseline model	Possible	Possible	Not possible (requires sov. bond holdings)
Extension (capital reg.)	Possible	Possible	Possible

TABLE 4.2: Three possible cases

Chapter 5

Corporate Bond Issues in Europe Before and During the Financial Crisis

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Abstract

While corporate bonds are an established, well-researched alternative to bank loans in the US, little is known about the relatively underdeveloped bond landscape in Europe. The design of efficient policies, such as the envisaged Capital Markets Union (CMU), however, requires a comprehensive understanding of the matter. I therefore investigate the bond issuing behavior of European corporations between 2004 and 2012, for which I use a self-compiled dataset, which reflects the rich interplay between firms' balance sheet characteristics, their location as well as macroeconomic indicators. I show three key results: First, a considerable fraction of companies, especially the larger ones, issued more bonds and a higher volume during the ongoing crisis than before. Second, corporations in the euro area's troubled periphery could not accomplish the transition towards capital markets funding as successfully as their counterparts in more stable EMU countries. Third, Italian companies substantially shortened the maturities of new issues during the crisis, while those head-quartered in the EMU's core issued longer term debt. Policy makers should therefore primarily aim at creating a level playing field: Solid firms should be able to raise capital markets funding at fair conditions during economic crises even if they are relatively small and located in unstable countries. A broader range of financing options for these companies may unlock considerable economic potential and increase the corporate sector's robustness to economic shocks.

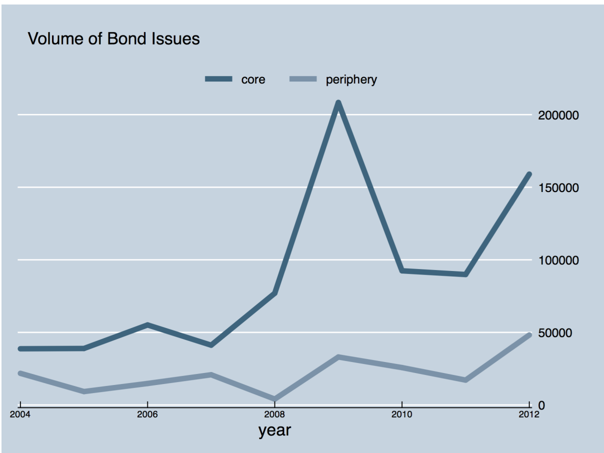
JEL classification: E31, E32, F44

Keywords: *Corporate Bond Issues, Europe, Before and After Crisis, Balance Sheet Characteristics, Maturity, Coupon Rates, Sovereign Risk*

5.1 Introduction

The funding pattern of European corporations underwent dramatic changes in the recent past. This was particularly true for the euro zone, where the banking and sovereign debt crisis disrupted traditional funding channels. Banks, for instance, reduced their lending significantly and – due to tightened regulatory requirements – are unlikely to fully return to their previous lending capacity anytime soon. The corporate sector, however, had become overly dependent on these loans until the onset of the crisis. The ratio of bank financing to capital market funding then equalled four to one in Europe as opposed to the reverse in the US (Reuters, 2015). Over the last few years companies thus seem to have looked for alternatives to bank loans and increasingly tapped the bond market directly. Yet, the latter is not sufficiently well developed in Europe. The Swiss Finance Council (2015), for instance, makes the following statement in a recent report: *'Had European capital markets issuance been similar to that of the US as a proportion of GDP between 2009 and 2014, the market would have been more than double its actual size: 9 trillion euros rather than 4 trillion euros'*.

While figure 5.1 indicates that the trend towards bond financing gained significant momentum during the last years in the core countries of the euro area, where the volume of corporate bond issuances by sample companies rose to an all-time high of about 220 billion euros in 2009, it also shows that this upward-trend was only very moderate in the euro zone's periphery. Such a differential may constitute a major disadvantage for corporates in Greece, Ireland, Italy, Greece, and Spain (GIIPS) which, by limiting their options to finance investment and growth, may potentially hinder the region's economic recovery as a whole.



The dark blue line documents the aggregate volume of bonds (in million euros) issued per year by sample companies in the euro area's core countries, while the light blue line depicts the volume issued by corporations in the periphery, i.e. the GIIPS. Bond market activity after 2008 significantly increased, mostly so in the core countries of the EMU.

FIGURE 5.1: Volume of bond issues in million euros over time

Yet, while long-lasting cross-country divergences of labor costs as well as fragile banking sectors have been widely identified as major impediments on the way to economic recovery in the EMU, therefore receiving increased attention from policy makers and regulators, the heterogeneous levels of activity on national capital markets have not been studied in sufficient detail for the European context so far. The availability of funding sources other than bank loans, however, most likely has an equally important role to play on the path to a sustainable recovery. A thorough understanding of recent developments on corporate debt capital markets would therefore be an important leap forward.

This paper represents a novel attempt to investigate the empirical characteristics of European corporate bond issuance in a well-founded descriptive and exploratory way. It focuses on the period from 2004 to 2012 and uses a self-compiled dataset, which reflects the rich interplay between firms' balance sheet characteristics, their location as well as macroeconomic country indicators during a time period of significant change. A number of novel findings arises from that setting: First, a considerable fraction of corporations issued more bonds after the crisis than before; this is especially true for comparatively large corporations and holds for the number of new bonds as well as their volume. The empirical results of this paper suggest that these developments may, in part, reflect the firms' attempt to compensate for the sudden decline in bank lending. Second, companies in the euro area's troubled periphery could not accomplish this transition as successfully as their counterparts in more stable EMU jurisdictions. The share of corporates in the GIIPS that increased their number and volume of bond issues after 2008, was approximately six percentage points smaller than the fraction of firms that did so in the euro zone's core. Location thus seems to significantly determine firms' financing choices. This holds even when a number of other well-established determinants for bond issuing activity are accounted for, which implies that firms are 'penalized' merely for being located in the 'wrong country'. European decision makers should thus design policies in ways that help eliminate unreasonable discrimination of that sort. Third, the maturities of new issues from Italian corporations shortened significantly post crisis, while firms in the euro zone's core refinanced themselves slightly more long-term. The latter may express the reluctance of Italian companies to lock in unfavorable funding terms during the financial turmoil and their hope to refinance themselves at more advantageous terms once the crisis would have resolved.

The emphasis of these important heterogeneities across countries and firm-types – with respect to the choice of companies to obtain direct capital market funding during financial turmoil as well as the maturities with which they issue corporate bonds – constitute new findings about European bond markets. They suggest that capital markets should become more accessible in general, that actions in this direction are particularly important for small and medium sized enterprises (SMEs) located in the GIIPS, and that the maturities of new bond issues react very differently to economic shocks across countries.

Improving the access to capital markets as an alternative to bank loans should foster sustainable firm investment, economic growth and a stable liability structure thereby increasing Europe's resilience to external shocks. The envisaged Capital Markets Union (CMU) attempts to do exactly that: It aims at creating deeper and more integrated capital markets across Europe by developing new funding channels and encouraging cross-border capital flows. The disadvantages of companies located in certain regions or individual countries of the euro area may therefore be mitigated. One crucial instrument to reach that goal is to level out national differences in contract and insolvency law, taxation, consumer protection as well as payments and security settlement systems. Simplifications and adaptations in these areas should make it easier for SMEs to gain access to capital markets funding as well. The findings of this paper suggest that European policies should particularly aim at improving capital markets access for companies in the GIIPS. The integration of European financial markets has been discussed prominently by European officials in recent months. A recent paper published by the European Commission (EC), co-written by its vice president Jyrki Katainen, for instance, claims that the EC will *'work with the industry to develop a pan-European private placement regime to encourage direct investment into businesses'* (Reuters, 2015). For that purpose, the commission intends to pursue a concrete plan of action to complete a European CMU by 2019.

The paper is subsequently structured as follows. Section 5.2 starts with a short literature overview on firm financing. Section 5.3 then discusses some important characteristics of the self-compiled data set and introduces the main measures and control variables, while section 5.4 presents the empirical model and discusses related estimation issues. The corresponding results and robustness checks are presented in section 5.5 before section 5.6 concludes.

5.2 Related literature

Macroeconomic studies on financial frictions have traditionally focused on total debt of firms as a homogeneous component and thus featured a single borrowing constraint. The composition of corporate funding and its determinants, however, may have crucial economic effects as well. This topic has been analyzed in different ways: Prominent contributions have examined substitution effects between loans and bonds on the aggregate level (Kashyap et al., 1993) or investigated companies' funding choices in microeconomic models instead. Holmström and Tirole (1997), for instance, establish a pecking order of financing choices where low net worth firms can only obtain financing from banks and are shut out of the bond market, while firms with high net worth have access to both, but ultimately use the cheaper bond financing. Bolton and Scharfstein (1996) argue that bank loans are more flexible than bonds and easier to restructure.

Bergloff and von Thadden (1994) highlight the positive complementarities between short-term bank loans and longer-term bond issuances. Denis and Mihov (2003), on the other hand, focus on firm size and show that smaller firms with higher revenue volatility tend to issue more bank debt while Bolton and Freixas (2000) derive a firm's equilibrium choice between equity, loans and bonds in a very general way.

Developments in recent years, however, raised the need for further research. These contributions either introduced frictions into macroeconomic models or tackled the issue empirically. Crouzet (2014), for instance, develops a model of firm dynamics, in which companies actively choose the composition of their borrowing, in order to understand the implications of varying debt structures for aggregate economic activity. His model is able to replicate important cross-sectional facts as well as variations over the business cycle. An application of the model concludes that an asymmetric shock generates a recession which is 15–30% deeper in a version of the model calibrated to the comparatively bank-dependent Europe than in one calibrated to the US. A similar composition effect of corporate debt is confirmed by Kashyap et al. (1994), who show that bank-dependent firms experience declines in inventory investment during recessions, and Adrian et al. (2012), who find that, in the US, bond financing actually increased between 2007 and 2009 to make up much of the gap. The authors thus question the existence of financing frictions and complement Kashyap et al. (1993) by highlighting the relatively larger role of the bond market compared to commercial paper in offsetting the contraction in bank credit and by using micro-level data on individual issues. Additionally, Becker and Ivashina (2013) document that small firms in particular reduce their investments when bank lending standards are tightened and attribute their conclusion to small companies' limited access to capital markets. DeFiore and Uhlig (2011), on the other hand, capture persistent long-run heterogeneities on the regional level as they compare the euro area to the US. Their asymmetric information model accounts for the fact that information availability on corporate risk is lower in Europe which causes interest rates to be higher and thus deters firms from tapping the bond market in the first place. Against this background, Eichengreen and Luengnaruemitchai (2004) argue that the active development of local currency corporate bond market in a number of Asian countries can be understood as a macro-prudential policy reaction to the large contraction in bank credit during the Asian crisis of 1997-1998.

Most studies are either theoretical or focus on the United States or aggregate economic developments. The findings of this paper therefore contribute to the literature by exploring the cross-country heterogeneities of corporate bond issues within Europe between 2004 and 2012, a period which featured significant transformations and market turmoil. The investigation derives a rich set of policy relevant insights concerning companies' financing choices and the conditions at which they borrow. It refines the understanding of what drives European corporate bond issues, which is necessary for the design of efficient policies, and highlights the need for the creation of a level playing field. Solid firms should be able to raise capital markets funding at fair conditions even during bad times, and irrespective of their location. The paper uses a novel, self-compiled data set, which combines firm-specific information with country variables and macroeconomic indicators.

5.3 Data and measurement issues

This paper explores a self-compiled data set, which has been built and merged from various sources including CapitalIQ, Thomson Datastream, Eurostat, OECD and Compustat. The sample covers firms from 18 countries, which comprise most EMU members plus Switzerland, Norway, Great Britain, Denmark and Sweden, and nine different sectors (see table 5.7 in the appendix). Overall, data has been collected for 5859 companies, 518 of which (8.85 percent) issued corporate bonds at least once between 2004 and 2012. Most of these companies are observed repeatedly. Many of them – such as Daimler, BASF, Deutsche Telekom (DEU) as well as OMV, Porr, Wienerberger (AUT) and Holcim, Richemont, Swisscom (CHE) – issued bonds on multiple occasions. British, German, and French companies naturally make up the largest groups in numbers. As far as sectors are concerned, most companies are part of the industrial or the consumer discretionary segment. Financials feature very distinct characteristics and differ from other sectors in numerous important ways. In order to prevent a bias of the results they have been dropped from this sample.

This composition of the sample has two important advantages: First, it offers interesting heterogeneities with respect to sectors, firm characteristics, geographical scope, macroeconomic country indicators, and time. Second, it allows us to capture firms which did not issue bonds at all. Importantly, – since this study is interested in the effects of the firms' characteristics and their location – bond issues are attributed to companies rather than the capital market, in which they have been issued. An issuance on the Swiss capital market, which has been very beneficial due to the low interest rate environment, by a German company, for instance, is thus essentially counted as German.

5.3.1 Dependent variables

5.3.1.1 Bond issues

As shown in 5.2 (a) as well as tables 5.8 to 5.12 in the appendix, French (590), British (378), Norwegian (309), German (238) and Swedish (230) companies have been the most active in absolute numbers and account for almost two-thirds of all issues of corporate bonds during the sample period. Norwegian, Swiss, and Austrian firms, on the other hand, dominate in relative terms: 23.4, 21.9 and 18.8 percent of all sample companies in these countries tapped the capital market at least once between 2009 and 2012, respectively. As far as sectors are concerned, corporations in the industrial and the consumer discretionary segment issue most bonds while telecommunication and utility companies are more active from a relative perspective. On aggregate, the sample firms have tapped the bond market on 2571 occasions during the period under review. Figure 5.2 (a) also illustrates that most of these issues occurred in the years after the onset of the crisis: While companies took on debt on the capital market only 189 times in 2005, they did so on 415 and 448 occasions in 2009 and 2012, respectively. Overall, the sample records 1433 issues between 2009 and 2012 and only 1138 in the pre-crisis period. While these have been initiated by 303 different firms before 2009, the number of corporations using direct bond financing increased to 380 in the second sample period. Out of these 380 companies 313 tapped the bond market more frequently during the crisis than in the years before, 5 just as regularly, 43 less often, and 19 were first-time issuers. 168 firms issued bonds before as well as during the crisis. Given that banks had to deleverage significantly during the turmoil, which impeded their loan origination capacity, one may conjecture that this decrease of funding supply was the primary reason for corporates' sudden run on capital markets.

In order to investigate whether firms changed their bond issuing behavior between the pre-crisis period and the crisis years, the analysis subsequently focuses on the 4,293 companies, which have been part of the sample for at least one year in both periods. Given that balance sheet data is available on a yearly basis and because the European banking and debt crisis gained full momentum towards the end of 2008, the latter is chosen as the cut-off between the two time windows. Results would remain unaltered, however, when the end of 2007 would be chosen instead. The paper aims at answering the following questions in this regard: *'What fraction of sample firms increased the frequency of bond issuance after 2008? In which European region did that happen to what extent? And which factors drove that change?'* In order to investigate if a company i increased its number of bond issues after 2008 and which firms may have done so in particular, the main dependent variable is defined as a dummy variable N_i which equals one if the average number of bonds a company issued per year after 2008, $\bar{x}_{09-12}$, is higher than the number of bonds the same firm issued before, $\bar{x}_{05-08}$, and zero otherwise:

$$N_i = \begin{cases} 1, & \text{if } \bar{x}_{09-12} > \bar{x}_{05-08} \\ 0, & \text{otherwise} \end{cases} \tag{5.1}$$

N_i thus takes on the value one if a firm issued bonds at all between 2009 and 2012 and if these were issued at a higher frequency than in the years before, and zero otherwise. The former is the case for 313 (7.3 percent) of all sample companies.

To ensure robustness, four variations of this dependent variable will be employed throughout this paper: First, the binary indicator as defined above; second, a binary indicator, which shows if a company gave out a larger volume of bonds during the crisis or not; third, a dummy for the construction of which the bond issue is attributed to a company's ultimate parent rather than the nominal issuer itself in order to capture the possibility that markets might care more about the parent than him. While it seems more plausible that financial market participants care first and foremost for the direct issuer's characteristics, it may well be that the financial backing of a solid parent company, for instance, is a decisive plus; such dummy settings are least prone to econometric specification issues and straightforward to interpret. Nevertheless, as a fourth option, I additionally use a continuous variable computed as the difference between the average number of bonds issued per year after 2008 and the average up to that point. The latter also better reflects the possibility that the frequency of a firm's bond issuances may have decreased between the two time windows.

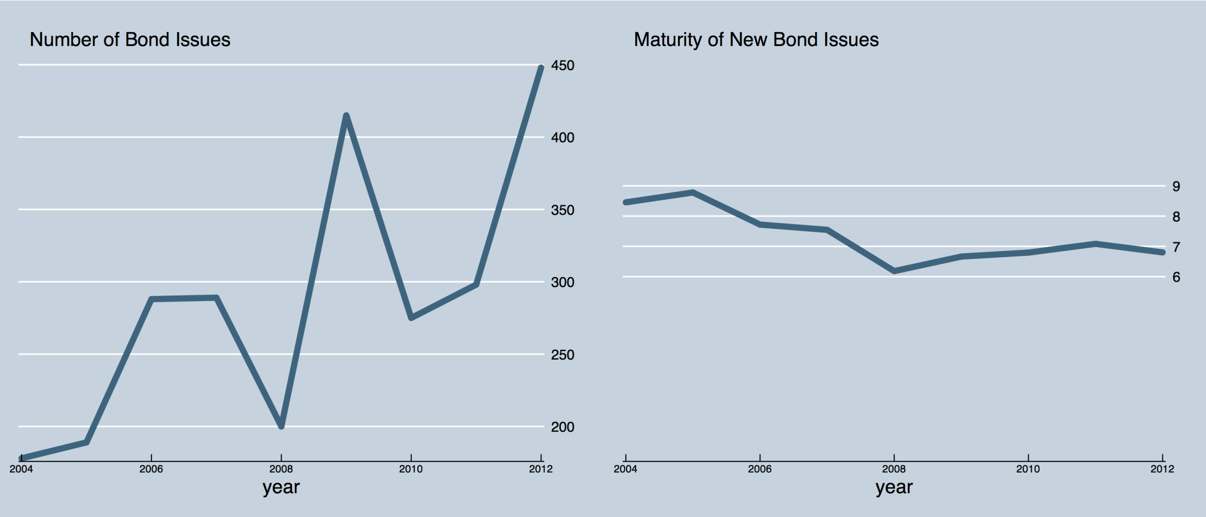
5.3.1.2 Maturities

Naturally, the number and volume of bonds are not the only important characteristic that should be considered. In fact, the onset of the crisis not only altered a company's access to capital markets in general but also the conditions at which new funding could be obtained. The maturity with which bonds are originated is an important feature of an issue and thus constitutes the second variable of interest in this paper. Figure 5.2 (b) illustrates that new issues became increasingly short-term during the crisis period. While the average corporate bond issued in 2005 had been scheduled to be fully repaid within 9.6 years, this number decreased by three years to 6.5 for new bonds in 2009. Overall, the average maturity decreased from approximately 8 years before 2009 to 7.1 years afterwards. Shorter maturities may express a company's desire to refinance itself at more favorable terms as soon as possible after the crisis would have resolved.

The key question with regards to these maturity developments is therefore framed as follows: *'Did the maturities of new bond issues decrease during the crisis? In which European region did that happen to what extent? And which factors drove that change?'* In order to determine if a company i indeed decreased the average maturity of its bond issues after 2008 and which firms may have done so specifically, the dependent variable is defined as

$$M_i = \bar{m}_{09-12} - \bar{m}_{05-08} \tag{5.2}$$

where $\bar{m}_{09-12}$ is the average maturity of bonds a corporation issued after 2008 and $\bar{m}_{05-08}$ represents the maturity of bonds the same firm issued before. A dummy variable, which takes on value one if $\bar{m}_{09-12} > \bar{m}_{05-08}$ and zero otherwise is used as a robustness check.



2005	2006	2007	2008	2009	2010	2011	2012
189	288	289	200	415	272	298	448

2005	2006	2007	2008	2009	2010	2011	2012
9.6	7.1	8.0	6.5	6.5	6.9	7.6	7.4

The graph and table on the left show the number of bond issues from sample companies over time; the graph and table on the right illustrate the average maturity of these issues. While European corporates tapped the capital markets more often over time, new bonds became increasingly short-term during the crisis.

FIGURE 5.2: Number and maturity of bond issues over time

5.3.2 Explanatory variables

5.3.2.1 Location

As discussed above, cross-country heterogeneities are a particularly interesting feature of this analysis which bears considerable policy relevance. This is especially true in Europe, where legal systems, tax systems, and capital market environments vary significantly, which implies that substantial economic potential may be unleashed by levelling out these differences in an appropriate way. Additionally, the financial crisis hit European countries with varying degrees. While non-EMU members such as Switzerland and Sweden along with certain EMU countries such as Germany managed to navigate through the downturn rather well, the GIIPS countries in Europe's periphery are still facing a number of difficult challenges. Structural labor market reforms and clean-ups of the banking sectors in these countries took center stage in recent policy efforts on the European level and have indeed come a long way, which should lay the foundations for future growth and more homogeneous economic developments within the EMU. The cross-country heterogeneities with regards to companies' financing options, however, have been widely neglected so far, although their implications may just be as significant. After all, it would constitute a considerable impediment to economic efficiency if good companies would be cut-off from funding only because they are located in a weaker geographic area.

The role of a firm's location for its change of bond issuing activity during the crisis and its choice of maturity is therefore the most important research question of this paper. Given the difficult market environment in the GIIPS and the associated loss of trust in sovereigns' capacity to repay their public debt, which is likely to have exerted a spillover effect on corporate bond markets as well, it seems natural to predict that capital markets in countries of the EMU's core were better able to absorb large issues of corporate bonds and that companies there are responsible for most of the enhanced importance of corporate bonds as a means of financing. The top-right table in figure 5.3 indeed shows that firms in non-GIIPS EMU countries, whose bond issues increased from 443 to 748 on aggregate, account for a significant part of the increase of capital market funding after 2008, while those located in Portugal, Ireland, Italy, Greece, Spain and Cyprus, could not follow to the same extent. German corporates strikingly increased their issues from only 74 before 2008 to 164 after that. A more detailed description of these developments for regions and individual countries over time is shown in the top-left graph and the table in the center of figure 5.3 as well as figures 5.6 and 5.7 in the appendix. A closer look on tables 5.9, 5.10, 5.11 and 5.12 reveals that the percentage point increase was most pronounced in Switzerland (plus 10.3 percentage points) and Belgium (plus 7.5 percentage points).

As far as the maturity of new bonds is concerned, it stands to reason that companies in the GIIPS may have issued shorter-term obligations after 2008 in order to refinance themselves again at better conditions as soon as possible once the crisis would have passed. Indeed, as shown at the bottom of table 5.3, the trend towards shorter maturities held especially true for firms located in peripheral EMU countries, where the average bond had been issued with a time frame of 11.3 years before 2008 and only 6.7 years afterwards, while companies in the EMU's core kept their maturity structure comparatively stable and issued even slightly more long-term obligations.

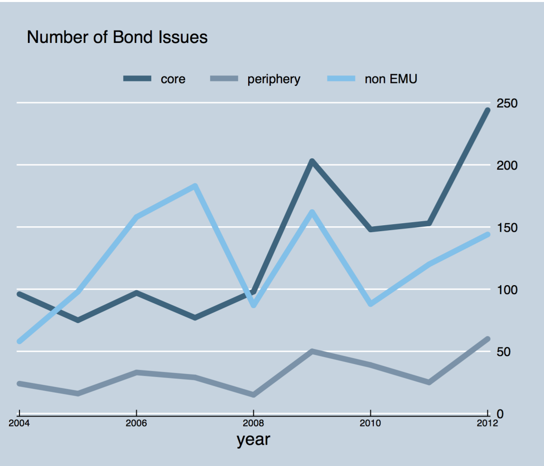
Based on these considerations, I define a dummy variable which equals one if a firm is located in Greece, Ireland, Italy, Greece or Spain:

$$PER_j = \begin{cases} 1, & \text{if located in the GIIPS} \\ 0, & \text{otherwise} \end{cases} \tag{5.3}$$

In the same way, the dummies 'EU' and 'EMU' indicate whether a company is headquartered in an EU and/or EMU member, respectively.[3] For a German corporation the 'EU' and the 'EMU' dummy would therefore be one while the 'PER' dummy would equal zero. I expect to find two results for the variable 'PER': First, that the fraction of

[3] The 'EU' dummy takes on the value one for the five GIIPS countries plus the seven core EMU countries Austria, Belgium, Germany, Finland, France, Luxemburg, the Netherlands plus Denmark, Great Britain, and Sweden, and zero for Switzerland and Norway. Cyprian firms only account for a minimal portion of this sample and an even smaller portion of bond issues but are otherwise included in the GIIPS category.

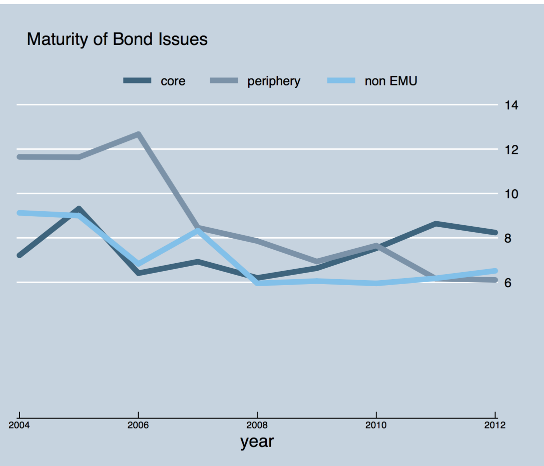
firms in the GIIPS, which intensified their bond issuing activity, is significantly smaller than that of companies in the EMU's core, i.e. a negative coefficient for the regression on N_i. Second, that corporations in the euro zone's periphery decreased the maturities of their new obligations during the crisis, i.e. a negative coefficient for the regression on M_i.



	2004-2008	2009-2012
Core EMU	443	748
Periphery EMU	111	171
EU (GBR, SWE, DNK)	361	262
Non-EU (CHE, NOR)	223	252
Total	1138	1433

Bond issues by country before and during the crisis

	AT	BE	CH	CY	DE	DK	ES	FI	FR	GB	GR	IL	IT	LU	NL	NO	PT	SE
bef	24	15	65	9	74	3	53	30	219	246	5	1	50	15	66	158	3	112
dur	40	46	101	0	164	12	64	42	371	132	1	0	99	22	63	151	6	118



	2004-2008	2009-2012
Core EMU	7.35	7.85
Periphery EMU	11.33	6.73
EU (GBR, SWE, DNK)	9.06	6.83
Non-EU (CHE, NOR)	6.84	5.80
Total	7.98	7.10

Top left: The dark blue line shows the number of bonds issued per year by sample companies in the euro area's core countries, while the light blue line depicts the number of bonds issued by corporations in the periphery, i.e. the GIIPS, and the bright blue line illustrates the number of issues in all other countries. Top right: The table shows the aggregate number of issues by region before and after 2008. Middle: The table shows the number of bonds issues by country before and after 2008. Bottom left: The graph shows the maturity of bond issues by region over time, for the same regions as the top left panel. Bottom right: The table shows the average maturity of new issues by region before and after 2008.

FIGURE 5.3: Bond issues by region over time

5.3.2.2 Firm characteristics

In order to find out whether it is really a firm's location that decisively influences its options to use bond financing and bond maturities, I employ several control variables in the empirical model for which descriptives are reported in table 5.13.

First, the company's *size* is an obvious candidate. This study uses the logarithm of a company's average asset size during the crisis period, i.e. between 2009 and 2012. As highlighted in table 5.1, the largest quarter of sample companies, which are distributed across regions in a rather balanced way, accounts for 89 percent of all corporate bond issues between 2005 and 2012 as well as an overwhelming fraction of their volume. Interestingly, this difference has been accentuated even further during the crisis years. Europe's largest corporations thus seem to have been able to adjust best to the decreasing support of the traditional banking sector, an observation that has been confirmed by Becker and Ivashina (2013), who find that – given their limited access to capital markets – small companies suffer most when bank funding dries up. Large firms' flexibility may be based on several factors: First, they are relatively well known by investors, more intensely covered by analysts, and they provide detailed information on a regular basis. Second, they tend to issue larger amounts, which lowers the fixed costs per issue such as rating costs, the fees charged by investment banks and other costs related to the issuing process. Third, bigger companies seem to benefit from lower coupon rates (see table 5.3). Fourth, they may be able to draw on previous experience and standardized procedures. Fifth, bonds can be issued on different markets and in various currencies. Large international companies may find it easier to tap foreign markets than smaller ones and may also benefit from exploiting relatively favorable opportunities in multiple locations. For these reasons, I expect to find a positive coefficient for this variable for the regression on the number of bond issues N_i as well as the maturities of new obligations M_i.

	2004-2008	2009-2012	2004-2008	2009-2012
Smallest quarter of firms	28	11	12992	2914
Quarter 2	50	52	20817	40011
Quarter 3	87	47	19496	9423
Largest quarter of firms	968	1290	485403	815117

TABLE 5.1: Number and volume of bond issues by size quartile before and after crisis

Second, the analysis controls for a firm's liability structure at the beginning of the crisis period. The upper half of companies, according to the leverage ratio, account for approximately 84 percent of all bond issues. The *debt-to-equity ratio*,[4] which varies

[4] Due to significant outliers, the variable is winsorized at the right tail at the two percent level.

considerably across geographical regions (companies in the EMU's periphery feature a higher debt-to-equity ratio than their peers in other euro zone countries or non-EMU members as shown in figure 5.4), therefore appears to be an important control variable for a proper empirical assessment. Given that every bond issue per se directly increases the debt-to-equity ratio, which would imply a purely mechanic positive impact, this study only uses the debt-to-equity ratio at the beginning of 2009, rather than its average during all crisis years. The variable's impact is unclear from an intuitive perspective: While a low debt-to-equity ratio may express a company's solidity, in which case the firm should be able to obtain bond funding quite easily and at favorable conditions, it may also reveal its deliberate choice to use other funding sources instead. The expected coefficient in a regression on the number of issues N_i would thus be positive in the first scenario and negative in the second case. Based on a similar reasoning, the coefficient in a regression on maturities M_i is ambiguous as well.

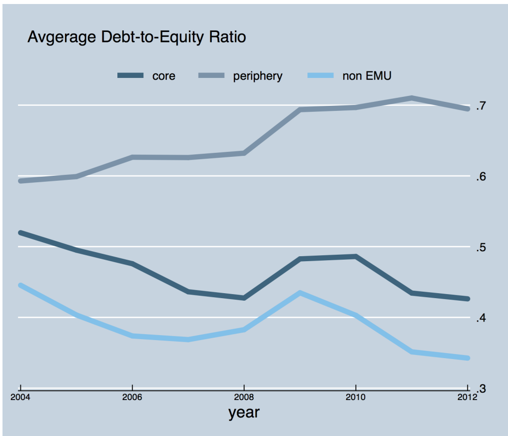


FIGURE 5.4: Debt-to-equity ratio by region over time

Finally, expanding firms may exhibit a stronger demand for additional funding, which is why the average *asset* and *sales growth* during the crisis years are used as additional explanatory variables. Investors may also be more willing to supply financing to relatively dynamic corporations, especially during the financial crisis when good investment opportunities were rare. Controlling for these variables is even more important against the background of table 5.2, which highlights the geographical dispersion of fast and slow growing companies. Most of the relatively dynamic firms are located in the core EMU or non-EMU countries rather than the GIIPS, whose corporations account for about 19 percent of the slowest growing half of firms during 2009 and 2012 but only for about 10 percent of the fastest growing companies. Given that dynamic firms may also be more successful in obtaining relatively long-term funding one may expect positive coefficients for the regressions on both dependent variables, N_i and M_i.

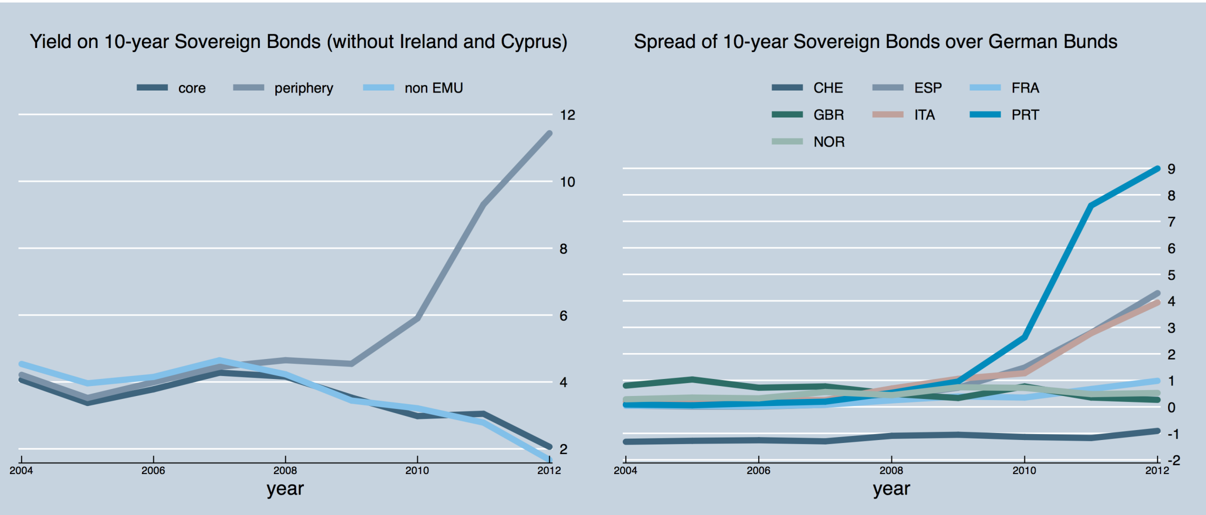
	Periphery EMU	Core EMU	Non-EMU	Total
In slowest growing half of firms	398	737	1009	2144
In fastest growing half of firms	215	795	1134	2144
Total	613	1532	2143	4288

TABLE 5.2: Number of firms by avg. sales growth between 2009 and 2012 and region

5.3.2.3 Macroeconomic indicators

Firm specific factors and location are not the only determinants of a company's access to capital markets and the conditions it offers to its creditors. In fact, bond markets strongly depend on the macroeconomic environment as well. Economic *growth*, for instance, may determine whether a company wants to take on new debt at all. Spain, Ireland and Greece were among the fastest expanding countries within the euro zone before the onset of the crisis but among the most contracting afterwards. Companies in these locations with a significant fraction of their sales in their home country may thus have thirsted for debt in the run-up to 2008 much more than between 2009 and 2012, in which case the lower increase of bond issues in the GIIPS may reflect a demand effect rather than a financing constraint. I would thus expect to find a positive coefficient for economic growth in the following regressions on the number of bonds as defined in (5.1). In terms of maturities, the sign of the growth-coefficient is unclear. In order to lock in favorable terms as long as possible companies may use the low interest environment, a consequence of intense central bank interventions, and go for longer maturities during downturns. This may be especially true for relatively solid corporations, whose creditworthiness is never in doubt, even during recessions. Firms may, however, also be more cautious and only borrow longer-term when their business environment returns to a more stable state.

Inflation rates exert a significant impact on the conditions on corporate bond markets as well. After all, even the most secure corporations generally have to pay their debt holders an interest rate above the inflation rate such that the obligation's real interest rate is positive. Negative coupon rates on corporate bonds – as in the beginning of 2015 – only occur under extreme circumstances and in near-deflationary environments. Additionally, the credit risk of the nation a firm is head-quartered in should play an important role, too. After all, the threat of a government default may trigger a number of negative consequences: Tax increases, uncertainty, and less subsidies for corporations are just a few of the possible externalities weak governments may inflict on their corporations. *Sovereign yields* serve as a good proxy for such risks. This study uses the spread of ten-year sovereign bonds over German Bunds – winsorized at the right tail at the five percent level – as illustrated in figure 5.5 (d). The latter has been widely used as a benchmark in recent years and shows considerable cross-country variation for the second half of the sample period. This is because countries such as Switzerland and Germany benefited tremendously from sound economic policies and their 'safe haven' reputation during the crisis, while others, such as Spain, Portugal and Greece, became more and more fragile and a target of market speculation. These observations also support the differentiation between GIIPS and core EMU countries used in the section about location (i.e. section 5.3.2.1). As reasoned above increased sovereign risk may inhibit a firm's options for bond issues and incentivize a company to issue shorter-term obligations in order to benefit from more favorable terms once the crisis would have passed. Overall, I would thus expect negative coefficients for the sovereign yield spread variable in all specifications. Corporate bonds usually pay a coupon, which lies above the interest rate on government bonds. The *slope of the yield curve*, which this paper defines as the difference between the ten-year yield on government bonds and the one-year yield and which is illustrated at the bottom right of figure 5.10,[5] should therefore have an important negative influence on the maturities of corporate bonds. Although its slope increased to a similar extent for all countries, which is why it is unlikely to explain the diverging maturity developments as observed in figure 5.3, it is included in the regressions on M_i for the completeness of the analysis.



Left: The dark blue line shows the average yield on ten-year sovereign bonds of the euro area's core countries, while the light blue line depicts the average yield on ten-year sovereign bonds of countries in the euro area's periphery, i.e. the GIIPS, and the bright blue line illustrates the average yield on government bonds of all other countries. Right: The graph shows the spread of the yield on ten-year sovereign bonds for selected countries over that of ten-year German Bundesanleihen 'Bunds'.

FIGURE 5.5: Sovereign bond yields

5 Greece is excluded, due to the excessively hump-shaped pattern of its yield curve in the last quarter of 2011 and the first quarter of 2012. Due to the market's expectation of a total debt restructuring program in about 12 months from then, during which Greece's creditors would accept a large reduction in their bond payoffs in exchange for a lower likelihood of outright default and preferential treatment in the event of further restructuring, its one-year yield was up to 40 percentage points higher than the yield on ten-year sovereign bonds at the time (Neely, 2012).

Against the background of such heterogeneous developments, it is surprising that the average newly issued bond offered an astonishingly stable average coupon rate throughout the entire sample period as illustrated in the center left graph of figure 5.10.[6] Several observations, however, are striking: First, the distribution of coupon rates became increasingly bipolar during the crisis (comparison of the graphs at the top of figure 5.10). While some companies were forced to promise significantly higher coupons to tap the market, others could keep them constant or managed to even reduce their funding costs. Second, as shown in table 5.3 large companies, which have already been shown to account for most of the intensified reliance on capital markets, enjoyed a significant funding advantage over their smaller peers throughout the entire sample period.[7] The crisis, however, further accentuated the difference as the largest quarter of firms only had to pay 0.14 percentage points extra while smaller firms had to lift their coupon rates by 1.17 percentage points. Volkswagen and BP, for instance, were able to issue numerous bonds at the lowest end of the coupon spectrum. Third, Swiss firms have consistently enjoyed the lowest interest rate costs on their debt throughout the entire sample period (center right graph of figure 5.10). Note, however, that these findings are purely descriptive as they do not account for issue maturity and other relevant factors and should thus be interpreted with caution.

	2004-2008	2009-2012	Change
Smallest quarter of firms	5.50	6.67	+1.17
Quarter 2	4.84	5.51	+0.67
Quarter 3	4.41	4.88	+0.47
Largest quarter of firms	3.87	4.01	+0.14
Total	4.72	5.16	+0.44

TABLE 5.3: Average coupon rate on bond issues by size quartile before and after crisis

5.4 The econometric model

As discussed above, this paper aims at exploring the developments with regards to two different aspects of bond issuance: (i) the number of newly issued bonds and (ii) their maturities. It also analyzes how these measures changed for different regions during the crisis in comparison to the years before. It does so by exploiting data on

6 Corporate coupons thus offered an attractive spread over ten-year-sovereign bond yields of the euro zone's core countries and non-EMU members (see the bottom left graph of figure 5.10).

7 See also Santos (2014), who shows that large US banks and big companies in the real sector enjoyed significant funding advantages over their smaller peers between 1985 and 2009. Note that in order to represent the full sample, table 5.3 averages the coupon rates over all bonds, also those with different maturities. The changes, however, are very similar if one only looks, for instance, at five-year bonds only.

firm location, company specific balance sheet characteristics, as well as macroeconomic country-level indicators. The following regression models are employed:

$$\mathrm{N}_{ijk} = \alpha + \beta_1 \mathrm{EMU}_j + \beta_2 \mathrm{PER}_j + \beta_3 \mathrm{EU}_j + \beta_4 Z_i + \beta_4 K_j + \mu_j + \lambda_k + \nu_{ijk} \quad (5.4)$$

$$\mathrm{M}_{ijk} = \alpha + \beta_1 \mathrm{EMU}_j + \beta_2 \mathrm{PER}_j + \beta_3 \mathrm{EU}_j + \beta_4 Z_i + \beta_4 K_j + \mu_j + \lambda_k + \nu_{ijk} \quad (5.5)$$

In both models i stands for company $i = 1, ..., 4283$, while $j = 1, ..., 18$ and $k = 1, ..., 9$ determine the firm's host country and the sector it is active in, respectively. N_{ijk}, which is a dummy that indicates whether a firm issued more bonds during the crisis than before, and M_{ijk}, which represents the change of the average maturity of bonds issued by a corporation between the two time frames, as well as their alternative definitions used as robustness checks have been defined in the section 'dependent variables'. In order to test the impact of a firm's location on these two outcome variables I include the EMU dummy EMU_j, the periphery dummy PER_j, and the EU dummy EU_j as defined the section 'location'. The coefficient estimates of these three dummies (β_1, β_2, β_3) are the key components of this analysis and will reveal whether firms in these regions reacted differently to the crisis in terms of (i) the use of direct capital markets funding in general (5.4) as well as (ii) the maturity with which new bonds were issued (5.5). While the intercept α will show what fraction of non-EU companies, i.e. Swiss and Norwegian firms, issued more bonds during the crisis than before in (5.4), it measures the change of the average maturity of an issue from a firm in that region in specification (5.5). Adding up α, β_3, and β_1 or α, β_3, β_1, and β_2, respectively, indicates the same two effects for corporations based in core EMU nations and the EMU's periphery, i.e. the GIIPS.

Based on the reasoning in previous sections I expect β_2 to be negative for model (5.4) as well as (5.5): The former would imply that the fraction of Greek, Irish, Italian, Portuguese, and Spanish companies in the sample which tapped the bond market more often during the crisis than before is smaller than that of corporations located in core euro area countries. Similarly, the latter would mean that firms in the GIIPS reduced the maturities of new bonds more than their counterparts in the core of the EMU.

The set of control variables is represented by the matrices Z_i and K_j. The former consists of a company's size, its debt-to-equity ratio at the beginning of the crisis period, and its sales/asset growth while the latter contains country characteristics such as macroeconomic growth, inflation, the country's yield spread over German bunds and the slope of the yield curve as discussed in sections 5.3.2.2 and 5.3.2.3. While sector-fixed effects λ_k are included in all specifications, country-fixed effects μ_j would interfere with macroeconomic country variables I am interested in and are therefore only applied as a robustness check; the error term is denoted by ν_{ijk}. To account for general correlations of companies within countries and sectors, I apply the standard cluster-robust variance estimator proposed by Liang and Zeger (1986). As the main explanatory variable of interest is a firms' location and because firms within a country are most likely subject to similar regulations and economic impact factors, this is the most intuitive form of clustering. To ensure robustness and since correlations are not necessarily confined within borders, however, I cluster on the sector level as well. Since dependent variables are defined in differences and explanatory variables in levels, I use the debt-to-equity ratio at the beginning of the crisis period in order to alleviate potential endogeneity issues in this regard. Yet, potential issues remain, since effects cannot always be fully disentangled in such a macroeconomic/financial setting. These are dealt with in various robustness checks and do not limit the nature of the main findings of this paper.

5.5 Results

5.5.1 Bond issues

Baseline estimates

The baseline outcomes of my empirical analysis are shown in table 5.4. The simplest specification as reported in column (1), in which I neither control for any firm specific characteristics nor for sector-fixed effects or macroeconomic variables, confirms two parts of my initial hypotheses: First, a significant fraction of firms increased their frequency of bond issues during the ongoing crisis as compared to the years before. This is especially true for firms located in non-EU member states such as Switzerland and Norway, where 19.4 percent of all sample firms tapped the bond market more frequently during the crisis than before, as well as those in core countries of the EMU such as Germany and France (10.0 percent).[8] Second, however, this shift towards the bond market was less pronounced for corporations in the euro zone's periphery, where only about 5.7 percent of the sample companies increased the frequency of bond issues.[9,10] The subsequent regressions and robustness checks confirm this negative impact on firms in the GIIPS, which suggests that they are experiencing a substantial disadvantage during the ongoing crisis because they are located in the wrong region. The inability of capital markets to provide them with funding could constrain their ability to foster growth and investment thereby causing economic inefficiencies that may contribute to the difficult recovery in the periphery overall. Weighting the average fractions of firms, which increased their use of bond borrowing, across geographies by the share of sample firms from those regions shows that 7.3 of all sample firms

8 10.0 is the sum of the constant and the EU and EMU dummies, i.e. 19.4 (α) - 16.4 (β_3) + 7 (β_1).

9 Significant on the 11 percent level;

10 Corporations in EU member countries that did not adopt the euro, i.e. Great Britain, Sweden, and Denmark, were even less likely to increase their frequency of bond issuance (3.0 = 19.4-16.4).

increased their activity on the bond market during the crisis as elaborated in section 5.3.1.1.[11]

The inclusion of sector-fixed effects in column (2) changes the magnitude of these effects but leaves the direction unchanged. Column (3) subsequently includes the company's size, measured in terms of its logarithmized assets, and finds the positive effect that was to be expected: All else equal, a firm that has two times as many assets as a smaller peer, is about 2.7 percentage points[12] more likely to increase its frequency of bond issues after 2008. The core results remain unaltered. In fact, the divergence between the core and the periphery of the EMU becomes even more pronounced: The fraction of non-EU, EMU, and GIIPS firms which increased the frequency of bond issues rises to 30.2 percent, 26.2 percent, and 19.3 percent,[13] respectively. These findings are confirmed across all specifications, which furthermore show that a company's debt-to-equity ratio is positively correlated with a company's change of bond issuance (column 4) while the inflation environment (5) exerts no significant impact on the bond issuing behavior of firms. The latter, however, is strongly correlated with the crisis dummy, which may explain its insignificance. Bond issues become more likely when economic growth in the respective home market is favorable (6), which suggests that the demand for capital is particularly strong when firms need it to finance their expansion, and when the country the firm is headquartered in is relatively safe, the latter of which is proxied by the spread of the country's ten-year-sovereign bonds over German bunds of the same duration (7). More comprehensive interpretations of the coefficients for these control variables have been discussed in previous sections of this paper.

Column (8) to (10) confirm these results for the alternative outcome variables defined in the section 'dependent variables': Specification (8) states that companies also increased the average bond volume per issue during the crisis, rather than just the number of issuances, while regression (9) documents that the results remain unchanged when bond issues are attributed to the borrower's ultimate parent rather than the nominal issuer itself. The outcomes also hold when the continuous variable – computed as the difference between the average number of bonds issued per year after 2008 and the average up to that point as defined in section 5.4 – is used as a dependent variable instead (column 10). The latter implies that the average company in core EMU countries issued 0.238 more bonds per year during the crisis period as compared to the years before 2009 while the average number of bond issues only increased by 0.192 for an average firm in the GIIPS. Note that country-clustered, robust standard errors are employed across all regressions and that specifications (2) to (10) include sector

[11] Given that the analysis focuses on corporations that have been active for at least one year in the pre and post crisis periods and considering that companies may have been more likely to drop out of the sample (default) in the GIIPS, this result is likely to even underestimate the true effect.

[12] $= 3.9 \times ln(2)$.

[13] $= 30.2 - 8.9 + 4.9 - 6.9$;

TABLE 5.4: Baseline Estimates

	baseline		firm specific		macroeconomic environment			alternative outcome variables		
	baseline	sector fixed	assets	debt/equity	inflation	growth	sovereign yield	volume	ultimate issuer	continuous
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Const.	0.194***	0.359***	0.302***	0.319***	0.290***	0.298***	0.297***	0.286***	0.269***	0.189*
	(24.69)	(11.98)	(9.20)	(9.41)	(7.60)	(9.19)	(9.98)	(7.03)	(5.53)	(1.80)
EMU	0.070***	0.074***	0.049***	0.070***	0.057***	0.048***	0.049***	0.046***	0.039**	0.049***
	(6.11)	(6.02)	(4.85)	(5.74)	(4.95)	(4.29)	(4.63)	(3.97)	(2.91)	(3.64)
PER	-0.043	-0.059**	-0.069***	-0.066***	-0.073***	-0.057***	-0.062***	-0.065***	-0.065***	-0.046*
	(-1.72)	(-2.61)	(-4.61)	(-2.96)	(-4.60)	(-3.24)	(-5.87)	(-3.85)	(-6.91)	(-1.91)
EU	-0.164***	-0.157***	-0.089***	-0.151***	-0.103***	-0.085***	-0.085***	-0.087***	-0.058	-0.003
	(-14.36)	(-10.30)	(-3.93)	(-8.38)	(-3.40)	(-3.77)	(-4.30)	(-4.55)	(-1.74)	(-0.11)
Assets			0.039***		0.039***	0.039***	0.039***	0.041***	0.046***	0.024*
			(3.80)		(3.83)	(3.76)	(3.78)	(3.97)	(4.66)	(1.77)
Debt/Equity				0.036***	0.005					
				(4.65)	(1.13)					
Inflation					0.008					
					(1.41)					
Growth						0.005*				
						(1.78)				
Sov. yield							-0.007***			
							(-4.65)			
Obs	4293	4283	4283	4283	4283	4283	4283	4283	4283	4283
R2	0.0343	0.0609	0.1673	0.0708	0.1681	0.1678	0.1683	0.1714	0.1890	0.0484
AIC	474.8204	379.2469	-133.7238	335.8444	-133.7531	-134.4356	-136.6828	-19.0202	55.1675	2072.9790

Standard errors in parentheses are clustered on the country-level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$. The coefficient for *constant* measures the general impact of the crisis on the frequency of firms' bond issuances, while the coefficients on *EMU* and *PER* show the impact for core EMU member countries and GIIPS, respectively. The standard estimate is a linear probability model. Estimation (1) is the baseline specification without sector-fixed effects and firm specific or macroeconomic control variables. Estimation (2) adds sector fixed-effects. Estimation (3) controls for the firm's average asset size during the 2009-2012 period. Estimation (4) controls for the debt-to-equity ratio at the beginning of 2009. Estimation (5) adds the inflation rate for the country a firm is headquartered in as an additional control variable. Estimation (6) adds economic growth. Estimation (7) also adds the home country's sovereign yield spread over German Bunds. Estimation (8) employs a different dependent 0/1 variable, which indicates if a firm increased '1' or decreased/kept unchanged '0' the average volume of a bond issue during the crisis. Estimation (9) uses the same set-up as estimations 1 to 6; but bond issues are attributed to the ultimate parent of a company rather than the nominal issuer. Estimation (10) uses a cont. variable as defined in section 5.4 as a dep. variable instead.

fixed-effects, which reveal that telecommunication and utility companies featured the strongest shift towards capital markets during the financial crisis.

Robustness checks

The outcome of specification (3) of the baseline estimates is subsequently exposed to a number of robustness checks. The regression documented in column (1) of table 5.5 clusters standard errors on the sector- rather than the country-level before country-fixed effects are included in the model which underlies the numbers reported in column (2). While the explanatory power increases slightly in the latter case, the basic results remain intact. One may also argue that the switch to capital market based funding was less pronounced for companies in the euro zone's periphery because of the relatively hostile business environment they were facing in their home markets, which decreased their need for additional funding in the first place. For that purpose regressions (3) and (4) split the sample in half, i.e. firms featuring high and low sales growth respectively. While the direction of the outcomes does not change, the results show that relatively fast growing corporations in the GIIPS were particularly disadvantaged, which implies that firms' inability to obtain capital markets financing may indeed have substantial effects on investment and growth. Specification (5) only keeps firms, which either never issued bonds or the overall level of long-term debt of which – i.e. obligations with maturities above one year – increased when they did. This check intends to only consider corporations which needed the additional funds to expand rather than just as a replacement for existing obligations. The fact that results are largely insensitive to these changes indicates the robustness of the major findings of this study and hints towards the potential financing constraint growing corporations may have faced in the euro zone's periphery. Interestingly, however, columns (6) to (9) reveal that the regression outcomes are largely driven by the biggest half of companies in this sample and by the half of firms, which feature the highest debt-to-equity level. While the former confirms the descriptive finding presented in section 5.3.2.2, which shows that large firms in the EMU's core accounted for the entire increase of the activity on Europe's bond markets, the latter may imply that highly indebted companies in particular could no longer obtain bank loans and were thus forced to tap the bond market instead. Finally, columns (8) to (10) document the regression outcomes using probit, logit and nearest neighbour[14] matching techniques, all of which verify the general increase of bond financing and the lower change in the EMU's periphery. Importantly, tables 5.14 and 5.15 in the appendix show that, by excluding one country or one sector at the time respectively, the results do not depend on specific countries or sectors.

[14] Companies are matched on asset size, debt-to-equity ratio, EU membership, pre crisis issue number and volume, and sector.

TABLE 5.5: Robustness

	sec	country	sales gr.		long-term	size		debt/equity		probit	logit	match
	cluster	fixed	high	low	debt	large	small	high	low			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Const.	0.302***	0.268***	0.296***	0.306***	0.101***	0.288***	0.039***	0.312***	0.139***	-0.633***	-1.098***	
	(14.38)	(11.12)	(3.71)	(4.03)	(4.36)	(6.02)	(9.02)	(3.67)	(3.42)	(-3.84)	(-3.54)	
EMU	0.049***	0.057***	0.054***	0.044***	0.024***	0.121***	0.011***	0.094***	0.015**	0.674***	1.398***	
	(6.40)	(4.67)	(5.74)	(3.10)	(4.77)	(6.56)	(3.50)	(5.48)	(2.42)	(7.44)	(7.98)	
PER	-0.069***	-0.097***	-0.067*	-0.065***	-0.025**	-0.084**	-0.016***	-0.097***	-0.022**	-0.522***	-0.985***	
	(-5.35)	(-15.97)	(-2.06)	(-6.07)	(-2.33)	(-2.82)	(-3.18)	(-3.87)	(-2.21)	(-3.23)	(-2.63)	
EU	-0.089***	-0.082***	-0.114***	-0.069*	-0.067**	-0.155***	-0.029***	-0.157***	-0.044***	-0.830***	-1.696***	
	(-3.64)	(-5.39)	(-5.46)	(-2.10)	(-3.05)	(-5.30)	(-8.60)	(-2.94)	(-4.38)	(-6.58)	(-6.88)	
Assets	0.039***	0.041***	0.037***	0.041***	0.016***	0.084***	0.004*	0.056***	0.014**	0.348***	0.684***	
	(8.99)	(3.63)	(3.29)	(4.32)	(9.27)	(6.41)	(1.94)	(4.82)	(2.63)	(11.50)	(12.35)	
SATE												0.023***
												(4.81)
Obs	4283	4283	2210	2073	4057	2155	2128	2165	2118	4283	4283	4283
R2	0.1673	0.1748	0.1678	0.1717	0.0666	0.2073	0.0147	0.1953	0.0651			
AIC	-151.72	-180.69	-14.17	-106.82	-3003.20	1007.41	-3624.13	897.40	-2355.64	1541.60	1537.02	

Standard errors in parentheses are clustered on the country-level. * p<0.10, ** p<0.05, *** p<0.01. The coefficient for *constant* measures the general impact of the crisis on the frequency of firms' bond issuances, while the coefficients on *EMU* and *PER* show the impact for core EMU member countries and GIIPS, respectively. The standard estimate is a linear probability model. Estimation (1) corresponds to estimation (3) in table 5.4 but uses standard errors clustered on the sector-level rather than the country-level. Estimation (2) adds country-fixed effects. Estimations (3) and (4) run the regression separately for the half of firms with the fastest and slowest growing sales. Estimation (5) excludes all firms, for which long-term debt decreased during a year in which the firm issued a corporate bond. Estimations (6) and (7) run the regression separately for the largest and the smallest half of firms. Estimations (8) and (9) run the regression separately for the half of firms with the highest and lowest debt-to-equity ratios. Estimation (10) runs a probit specification. Estimation (11) runs a logit specification. Estimation (12) runs a nearest neighbor specification that matches firms on asset size, debt-to-equity ratio, EU membership, pre crisis issue number and volume, and sector.

5.5.2 Maturities

The empirical analysis also confirms the initial conjectures about maturity developments. As shown in table 5.6, the average maturity of new bond issues by companies in the EMU's periphery dropped by about five years during the crisis period as compared to the years before.[15] Firms in other regions, on the other hand, kept it constant and corporations in the core countries of the EMU even increased it by about two years. Column (1), which reports the outcome of the baseline estimation and does not control for any firm specific or macroeconomic country indicators, suggests a decrease by about 5.34 years for firms in the GIIPS while the coefficient for firms in the core countries is positive. These findings remain robust when I include the control variable asset size (2), for which a positive effect can be observed indicating that larger corporations – besides lower coupon rates – managed to attract more long-term funds. They are also confirmed by columns (3), (4), (5) and (6) which report the results of regressions that control for economic growth and inflation in the firm's home market as well as the country's yield spread over ten-year German bunds, the slope of its yield curve and a host nation's EU membership status. None of these variables, however, are found to be significant or change the findings with regards to the core determinants of this paper. The same holds true when issues are attributed to the borrower's ultimate parent (7) or when standard errors are clustered on the sector rather than the country level (8). The results hold for large as well as small companies (9, 10), where the respective coefficients are significant at least on the 15 percent level. Eventually, the same effects are revealed when looking at the 'extensive margin' as documented in column (11), where the dependent dummy variable indicates whether a firm increased or decreased the average maturity of its issues during the crisis.

Importantly, however, the findings regarding the periphery ('PER') dummy seem to be largely driven by the eleven Italian corporations, which reduced the maturity of their issues radically from 15.2 years before to 7.3 years during the crisis, rather than the more general distinction between core EMU countries and GIIPS. The latter is shown in table 5.16 in the appendix, which reports the coefficients when all firms of one country are excluded at a time, as well as figures 5.8 and 5.9, which depict the average maturity of issues by country over time. Similarly, excluding firms from the consumer discretionary segment also lowers the robustness of the 'PER' dummy (see table 5.17), although it is still significant on the 14 percent level. An overall assessment across all specifications therefore confirms the strong maturity reduction of corporate bonds in the euro zone's periphery, but also highlights that this outcome is largely driven by Italian companies.

[15] It is important to note that the number of observation drops to 168 as one can only compare the maturity of new bonds if a firm issued obligations in the pre as well as the post 2008 periods.

TABLE 5.6: Maturity

	baseline	assets & debt/equity	growth & inflation	sov. yield	slope of yield curve	EU	ultimate issuer	sec. cluster	size		increase yes/no
									large	small	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Const.	2.103	1.493	1.778	1.378	-3.720***	2.098	-3.709***	-3.709***	1.642	4.800***	0.726***
	(1.21)	(1.00)	(1.21)	(0.83)	(-4.23)	(1.45)	(-3.48)	(-5.43)	(0.31)	(4.41)	(3.69)
EMU	1.904**	1.946**	1.939***	2.186***	1.823**	2.383***	1.784**	1.784*	1.839**	1.299	0.177**
	(2.71)	(2.59)	(3.05)	(3.25)	(2.44)	(3.77)	(2.86)	(2.07)	(2.27)	(1.15)	(2.15)
PER	-5.347**	-5.602**	-4.960**	-4.369	-5.367**	-5.365**	-2.682**	-2.682***	-3.562**	-7.761*	-0.234*
	(-2.40)	(-2.62)	(-2.25)	(-1.68)	(-2.33)	(-2.39)	(-2.34)	(-3.72)	(-2.49)	(-2.00)	(-2.02)
Assets		0.357*	0.347*	0.373*	0.382*	0.391**	0.297	0.297**	0.340	0.011	0.034
		(1.93)	(1.77)	(1.96)	(1.87)	(2.35)	(1.52)	(2.49)	(0.42)	(0.03)	(1.50)
Debt/Equ.		0.254									
		(0.62)									
Growth			0.249								
			(1.64)								
Inflation			-0.274								
			(-0.66)								
Sov. yield				-0.709							
				(-0.93)							
Yield curve					-0.064						
					(-0.81)						
EU						-1.075					
						(-1.01)					
Obs	168	168	168	168	166	168	150	150	84	84	168
R2	0.1793	0.1925	0.1986	0.1943	0.1980	0.1943	0.1838	0.1838	0.1792	0.2535	0.1545
AIC	1038.5592	1039.8525	1040.5660	1039.4637	1027.6174	1039.4731	825.5563	807.5563	482.3063	549.1993	236.2031

Standard errors in parentheses are clustered on the country-level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$. The coefficient for *constant* measures the general impact of the crisis on the maturity of firms' bond issuances, while the coefficients on *EMU* and *PER* show the impact for core EMU member countries and GIIPS, respectively. Estimation (1) is the baseline specification without firm specific or macroeconomic control variables. Estimation (2) controls for the firm's average asset size during the 2009-2012 period and its debt-to-equity ratio at the beginning of 2009. Estimation (3) adds the inflation rate as well as the growth rate for the country a firm is headquartered in as control variables. Estimation (4) controls for the home country's sovereign yield spread over German 'Bunds'. Estimation (5) uses the slope of the yield curve as an additional explanatory variable. Estimation (6) adds a dummy, which indicates if a firm is located in an EU country. Estimation (7) uses the same set-up as estimations 1 to 6; but bond issues are attributed to the ultimate parent of a company rather than the nominal issuer. Estimation (8) clusters standard errors on the sector-level rather than the country level. Estimations (9) and (10) run the regression separately for the largest and the smallest half of firms. Estimation (11) employs a different dependent 0/1 variable, which indicates if a firm increased '1' or decreased/kept unchanged '0' the average maturity of a bond issue during the crisis.

5.6 Discussion and conclusion

Numerous papers have analyzed firms' financing choices theoretically or empirically for the US. It is also well established that European corporations rely relatively strongly on bank loans rather than capital markets, which contrasts with the situation in the US. Most studies, however, have ignored important heterogeneities with regards to firms' financing behavior across European countries. The latter seem to have been further reinforced by the recent financial crisis. The purpose of this paper is to shed light on these differences and to elaborate on how firms reacted to the onset of the crisis and the reduction of bank lending in terms of the number and volume of bond issues as well as their maturities.

It investigates the bond market activity of European firms between 2004 and 2012, for which it uses a unique, self-compiled dataset that reflects the rich interplay between firms' balance sheet characteristics, their location as well as macroeconomic indicators. The paper derives three major findings: First, a significant share of sample corporations tapped the bond market more often and issued a higher volume of bonds during the ongoing crisis than before. This is particularly true for relatively large firms as well as those located in core countries of the euro area or those in the non-EU countries Switzerland and Norway. Second, companies in the euro zone's troubled periphery did not intensify their financing activity on the bond market as strongly as their counterparts in more stable EMU countries. The fraction of companies in the GIIPS region that issued a higher number and volume of bonds after 2008 than before was about 4.3 to 7 percentage points lower than that of firms in the EMU's core. Third, Italian corporations shortened the maturities of newly issued bonds by nearly eight years during the crisis, while those located in the EMU's core issued longer term debt.

The relatively hesitant move towards capital market funding by firms in the EMU's periphery could be a reflection of dysfunctional capital markets, which may have been less able to absorb large issues of corporate bonds than the ones in Europe's core. Their inability to provide funding to expanding firms could substantially impede investment and economic growth, thereby slowing down the periphery's economic recovery and making it overly susceptible to problems in the banking sector. Shortened bond maturities in Italy on the other hand may express the firms' attempt to avoid locking in long-term commitments at unfavorable terms and to benefit from more advantageous funding conditions as soon as possible after the crisis would have resolved. These novel findings on European bond markets emphasize important cross-country heterogeneities, which suggest that a company's location has a decisive impact on its refinancing choices and conditions even when a number of important other determinants are controlled for.

The establishment of the envisaged European Capital Markets Union (CMU), which aims at creating deeper and more integrated capital markets throughout Europe by establishing alternative funding channels and encouraging capital flows across borders, seems particularly important against this background. It may help mitigate inefficient side-effects of such variations. The CMU should level out national differences in contract and insolvency law, taxation, consumer protection, and payments and security settlement systems. Such measures intend to make capital markets more accessible and should be advantageous for SMEs, which contribute to almost 60 percent of value added in Europe and two-thirds of overall employment (Swiss Finance Council, 2015), particularly those located in regions which offer limited access to capital market funding. These steps should foster sustainable firm investment, growth and a stable liability structure thereby increasing Europe's resilience to external shocks and paving the path to a sustainable economic recovery.

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Appendix

5.A Descriptives

TABLE 5.7: Number of firms by country and sector

	Energy	Material	Industr.	Cons.Disc.	Cons.Staples	Health Care	IT	Telecom	Utilities	Total
AUT	3	12	25	12	7	2	15	1	5	82
BEL	3	18	14	17	13	15	28	2	6	116
CHE	3	24	75	37	17	30	30	2	12	230
CYP	6	6	10	11	7	1	2	1	0	44
DEU	10	52	180	175	35	68	196	11	25	752
DNK	2	6	49	24	12	21	20	1	5	140
ESP	6	18	31	26	13	12	9	3	11	129
FIN	1	16	43	19	9	6	30	1	2	127
FRA	9	47	148	173	60	65	178	12	16	708
GBR	172	231	416	461	98	187	345	33	40	1983
GRC	5	34	54	69	29	8	15	6	5	225
IRL	6	17	14	10	8	8	9	1	0	73
ITA	10	23	60	83	13	14	32	5	27	267
LUX	5	4	4	9	10	1	2	2	3	40
NLD	8	11	50	26	17	10	29	7	1	159
NOR	92	14	48	21	21	18	46	2	2	264
PRT	1	12	13	15	4	0	4	2	2	53
SWE	17	38	114	84	17	65	114	12	6	467
Total	359	583	1348	1272	390	531	1104	104	168	5859

TABLE 5.8: Number of firms with bond issues by country and sector

	Energy	Material	Industrial	Cons. Disc.	Cons. Staples	Health Care	IT	Telecomm.	Utilities	Total
AUT	2	5	7	2	0	1	1	0	1	19
BEL	1	3	1	3	2	4	2	1	2	19
CHE	1	6	17	5	4	8	1	1	8	51
CYP	2	0	0	1	0	0	0	0	0	3
DEU	0	7	24	15	5	4	6	4	5	70
DNK	0	0	3	0	1	1	0	1	1	7
ESP	1	1	3	1	1	0	1	1	4	13
FIN	1	6	5	2	1	0	3	1	1	20
FRA	2	7	24	20	7	6	12	3	6	87
GBR	6	7	8	23	6	3	3	4	9	69
GRC	0	0	1	0	0	0	0	1	0	2
IRL	0	0	0	0	0	1	0	0	0	1
ITA	2	2	7	8	1	0	0	1	9	30
LUX	1	2	1	2	0	0	0	1	0	7
NLD	0	3	2	1	4	0	2	4	1	17
NOR	38	3	15	2	6	0	2	1	2	69
PRT	0	3	1	0	1	0	0	0	2	7
SWE	1	3	11	1	2	3	3	2	1	27
Total	58	58	130	86	41	31	36	26	52	518

country	no issue	issue	total
AUT	68	12	80
BEL	108	8	116
CHE	197	27	224
DEU	691	31	722
DNK	134	3	137
ESP	123	5	128
FIN	114	11	125
FRA	637	54	691
GBR	1871	47	1918
GRC	218	2	220
IRL	70	0	70
ITA	242	17	259
LUX	28	4	32
NLD	141	15	156
NOR	204	46	250
PRT	45	6	51
SWE	433	15	448
Total	5324	303	5627

TABLE 5.9: Number of firms with/without at least one issue pre crisis by country

country	no issue	issue	total
AUT	56	13	69
BEL	84	14	98
CHE	150	42	192
DEU	559	56	615
DNK	116	4	120
ESP	98	12	110
FIN	95	16	111
FRA	510	63	573
GBR	1288	43	1331
GRC	201	1	202
IRL	56	1	57
ITA	204	24	228
LUX	29	5	34
NLD	107	11	118
NOR	154	47	201
PRT	41	2	43
SWE	374	26	400
Total	4122	380	4502

TABLE 5.10: Number of firms with/without at least one issue during crisis by country

country	no issue	issue	total
Energy	293	37	330
Material	512	34	546
Industrial	1229	69	1298
Consumer Disc.	1174	42	1216
Consumer Staples	345	27	372
Health Care	487	15	502
IT	1057	20	1077
Telecomm.	78	21	99
Utilities	123	38	161
Total	5298	303	5601

TABLE 5.11: Number of firms with/without at least one issue pre crisis by sector

country	no issue	issue	total
Energy	255	39	294
Material	417	45	462
Industrial	954	100	1054
Consumer Disc.	863	64	927
Consumer Staples	279	30	309
Health Care	397	22	419
IT	793	20	813
Telecomm.	54	19	73
Utilities	100	41	141
Total	4112	380	4492

TABLE 5.12: Number of firms with/without at least one issue during crisis by sector

TABLE 5.13: Descriptive statistics

Variable		Mean	Std. Dev.	Minimum	Maximum	Obs.
N_i standard	overall	0.07	0.26	0.00	1.00	N = 4427
	between		0.26	0.00	1.00	n = 4293
	within		0.02	- 0.43	0.57	$\bar{T}$ = 1.03121
N_i volume increase yes/no	overall	0.07	0.26	0.00	1.00	N = 4427
	between		0.26	0.00	1.00	n = 4293
	within		0.02	- 0.43	0.57	$\bar{T}$ = 1.03121
N_i ultimate issuer	overall	0.08	0.27	0.00	1.00	N = 4427
	between		0.27	0.00	1.00	n = 4293
	within		0.02	- 0.42	0.58	$\bar{T}$ = 1.03121
N_i continuous	overall	0.03	0.32	- 4.75	5.50	N = 4427
	between		0.31	- 2.60	5.50	n = 4293
	within		0.11	- 4.47	4.53	$\bar{T}$ = 1.03121
Maturity	overall	6.76	4.80	1.00	60.50	N = 368
	between		4.80	1.00	60.50	n = 368
	within		0.00	6.76	6.76	T = 1
M_i standard	overall	- 0.99	5.80	- 52.33	10.60	N = 170
	between		5.80	- 52.33	10.60	n = 170
	within		0.00	- 0.99	- 0.99	T = 1
M_i ultimate issuer	overall	- 0.56	5.03	- 23.46	34.00	N = 227
	between		5.03	- 23.46	34.00	n = 227
	within		0.00	- 0.56	- 0.56	T = 1
EMU	overall	0.51	0.50	0.00	1.00	N = 4293
	between		0.50	0.00	1.00	n = 4293
	within		0.00	0.51	0.51	T = 1
PER	overall	0.14	0.35	0.00	1.00	N = 4293
	between		0.35	0.00	1.00	n = 4293
	within		0.00	0.14	0.14	T = 1
EU	overall	0.91	0.28	0.00	1.00	N = 4293
	between		0.28	0.00	1.00	n = 4293
	within		0.00	0.91	0.91	T = 1
Assets	overall	3.72	21.18	0.00	638.22	N = 4427
	between		21.43	0.00	638.22	n = 4293
	within		0.48	- 17.62	25.06	$\bar{T}$ = 1.03121
Debt/Equity*	overall	0.49	0.76	0.00	3.84	N = 4427
	between		0.75	0.00	3.84	n = 4293
	within		0.09	-1.43	2.40	$\bar{T}$ = 1.03121
Sales growth**	overall	7.02	21.01	- 25.19	70.13	N = 4288
	between		20.76	- 25.19	70.13	n = 4165
	within		3.75	- 40.64	54.68	$\bar{T}$ = 1.02953
Inflation rate	overall	1.92	1.01	- 4.50	4.50	N = 4293
	between		1.01	- 4.50	4.50	n = 4293
	within		0.00	1.92	1.92	T = 1
Economic Growth	overall	- 0.41	1.64	- 8.54	6.56	N = 4293
	between		1.64	- 8.54	6.56	n = 4293
	within		0.00	- 0.41	- 0.41	T = 1
Sov. yield spread/Bunds**	overall	0.43	1.25	- 2.56	4.14	N = 4293
	between		1.25	- 2.56	4.14	n = 4293
	within		0.00	0.43	0.43	T = 1

* winsorized, 2 % of observations modified; ** winsorized, 5 % of observations modified.

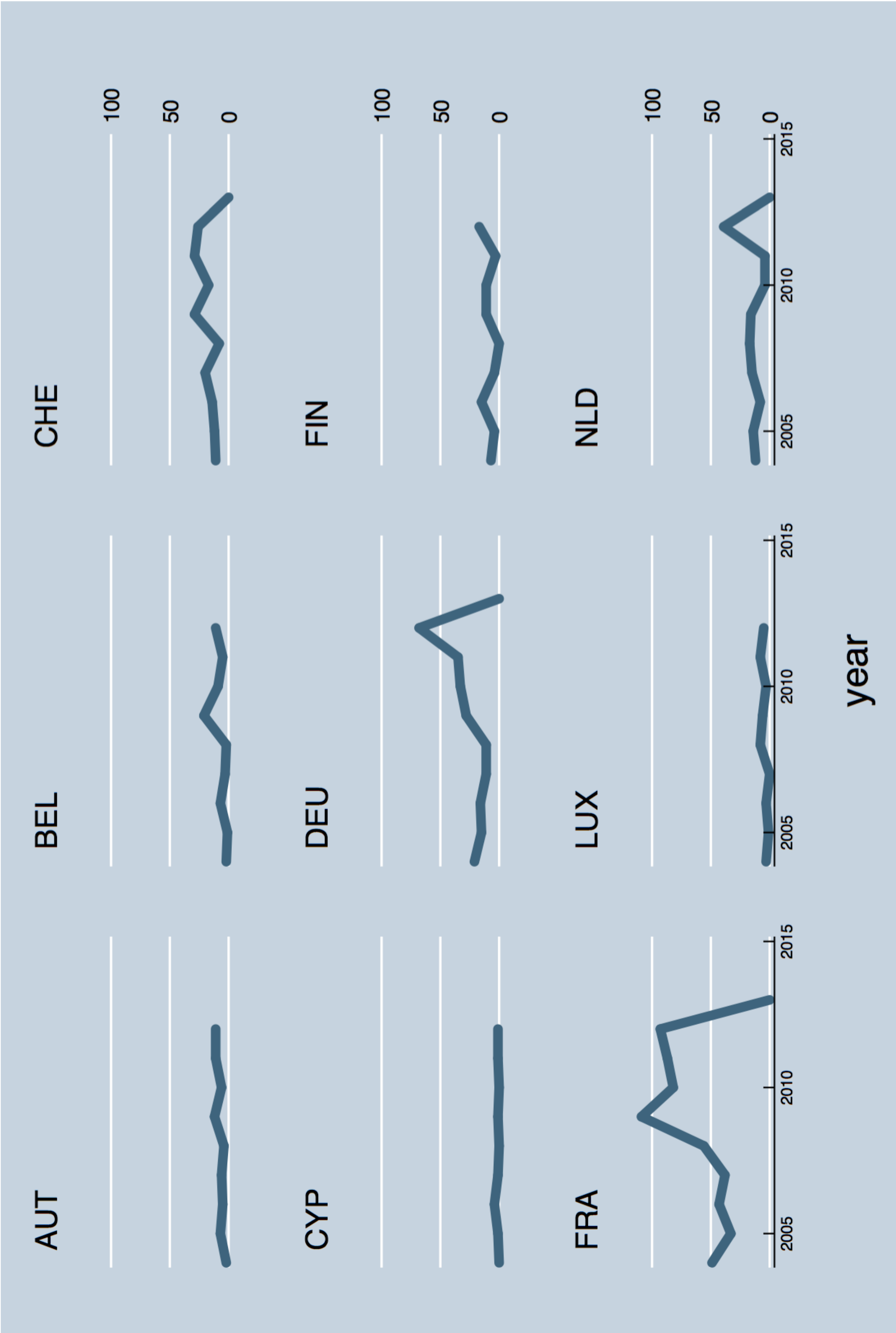


FIGURE 5.6: Number of corporate bond issues by country over time

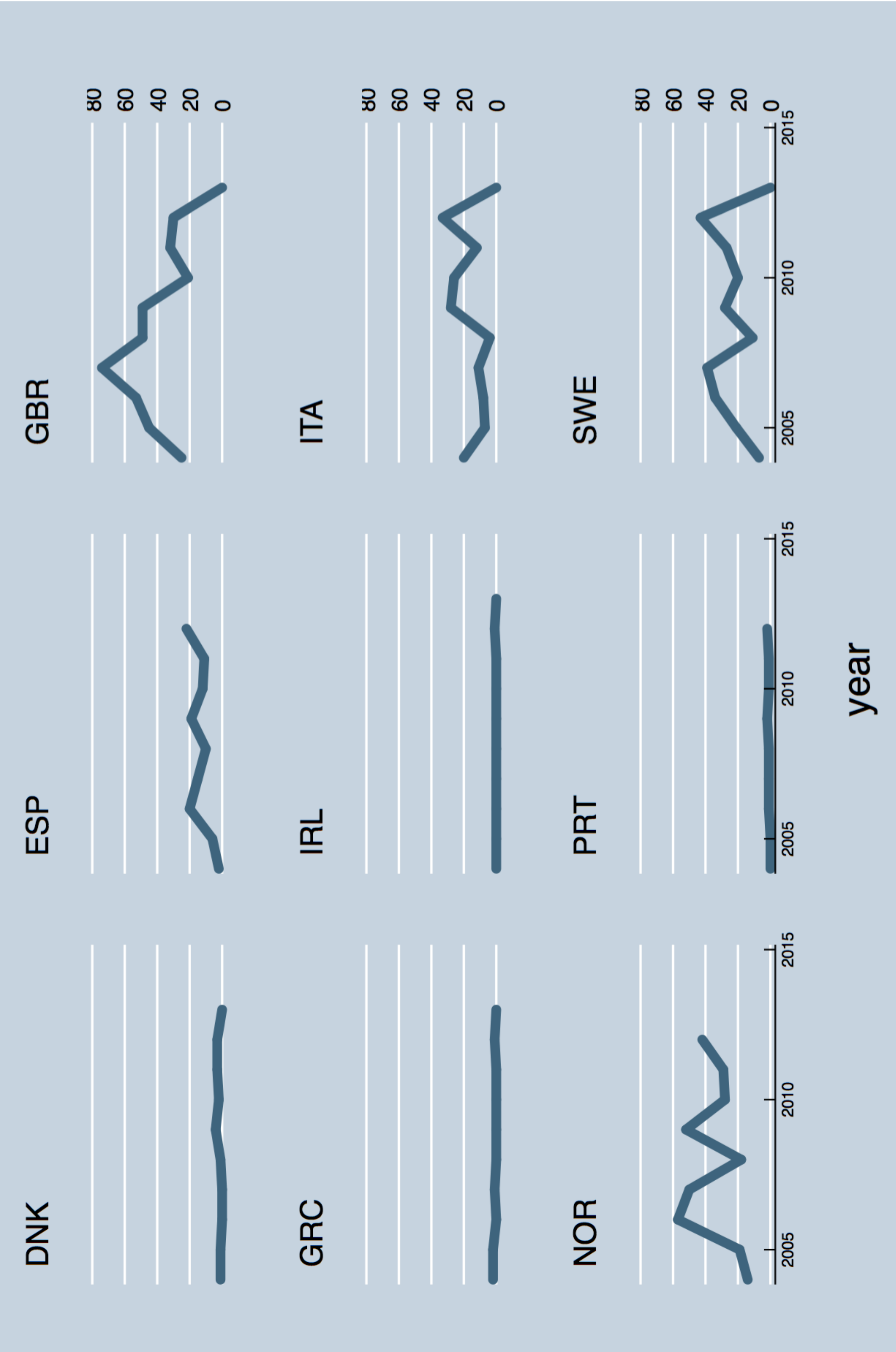


FIGURE 5.7: Number of corporate bond issues by country over time cont'd

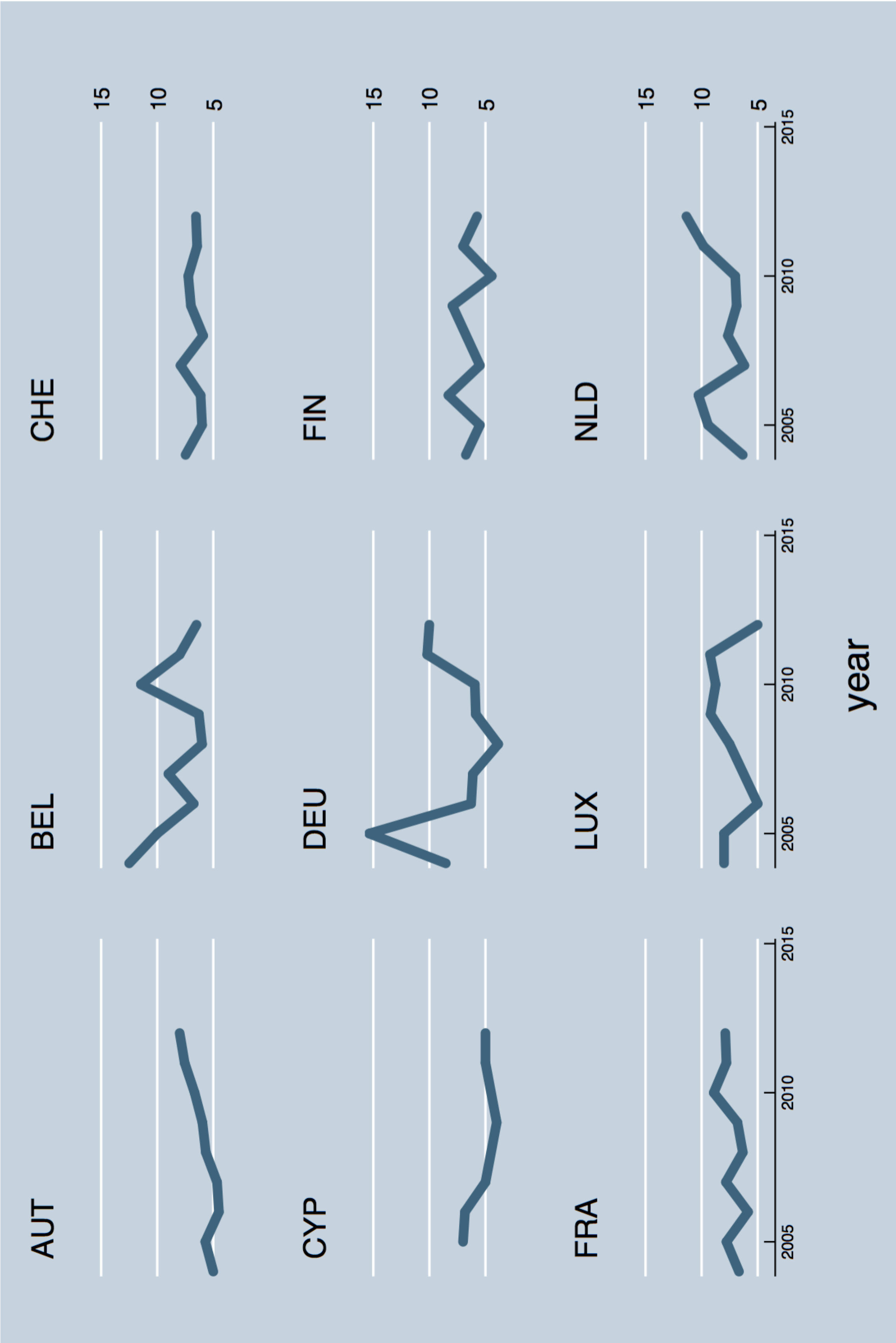


FIGURE 5.8: Maturity of corporate bond issues by country over time

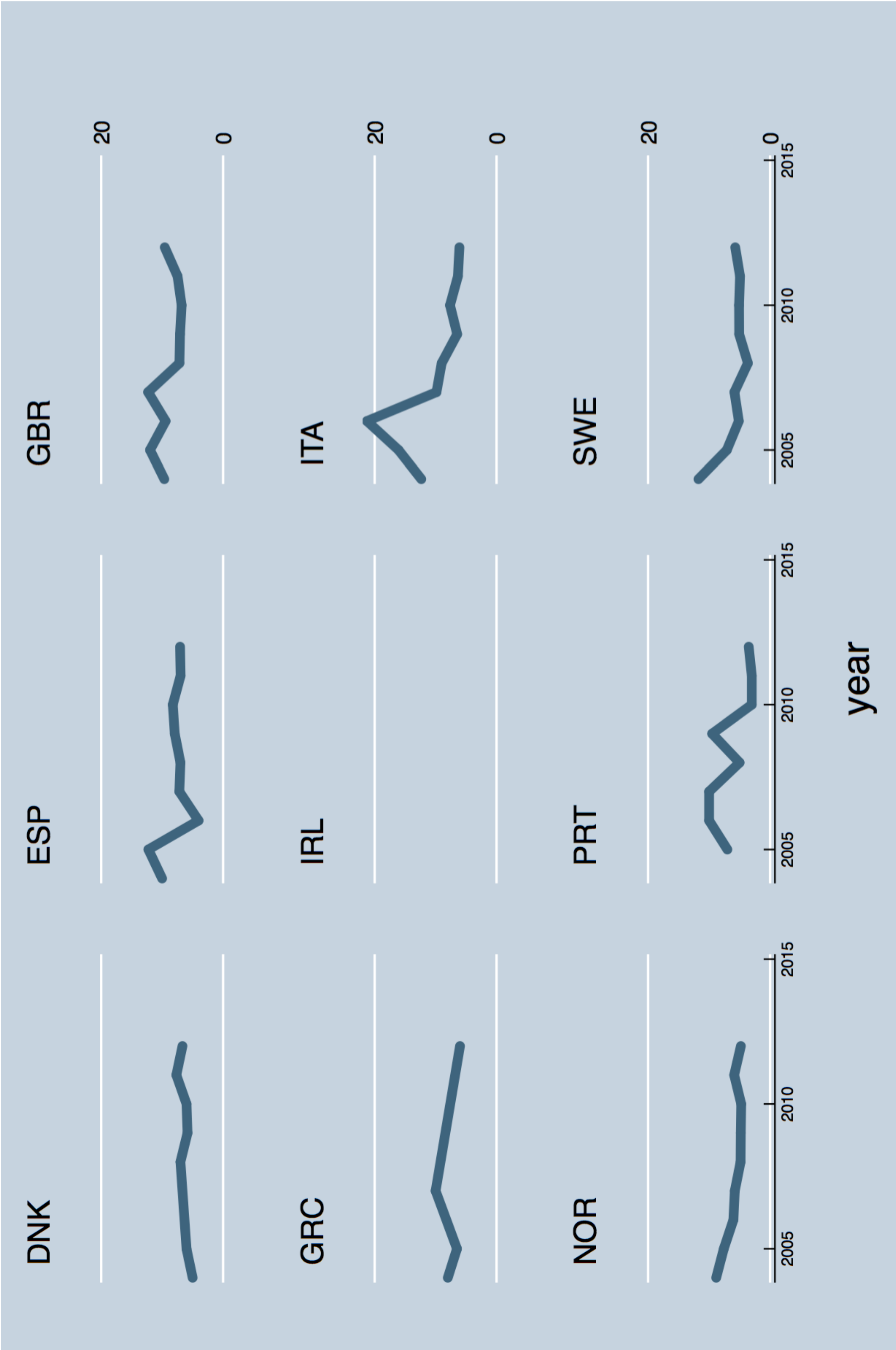
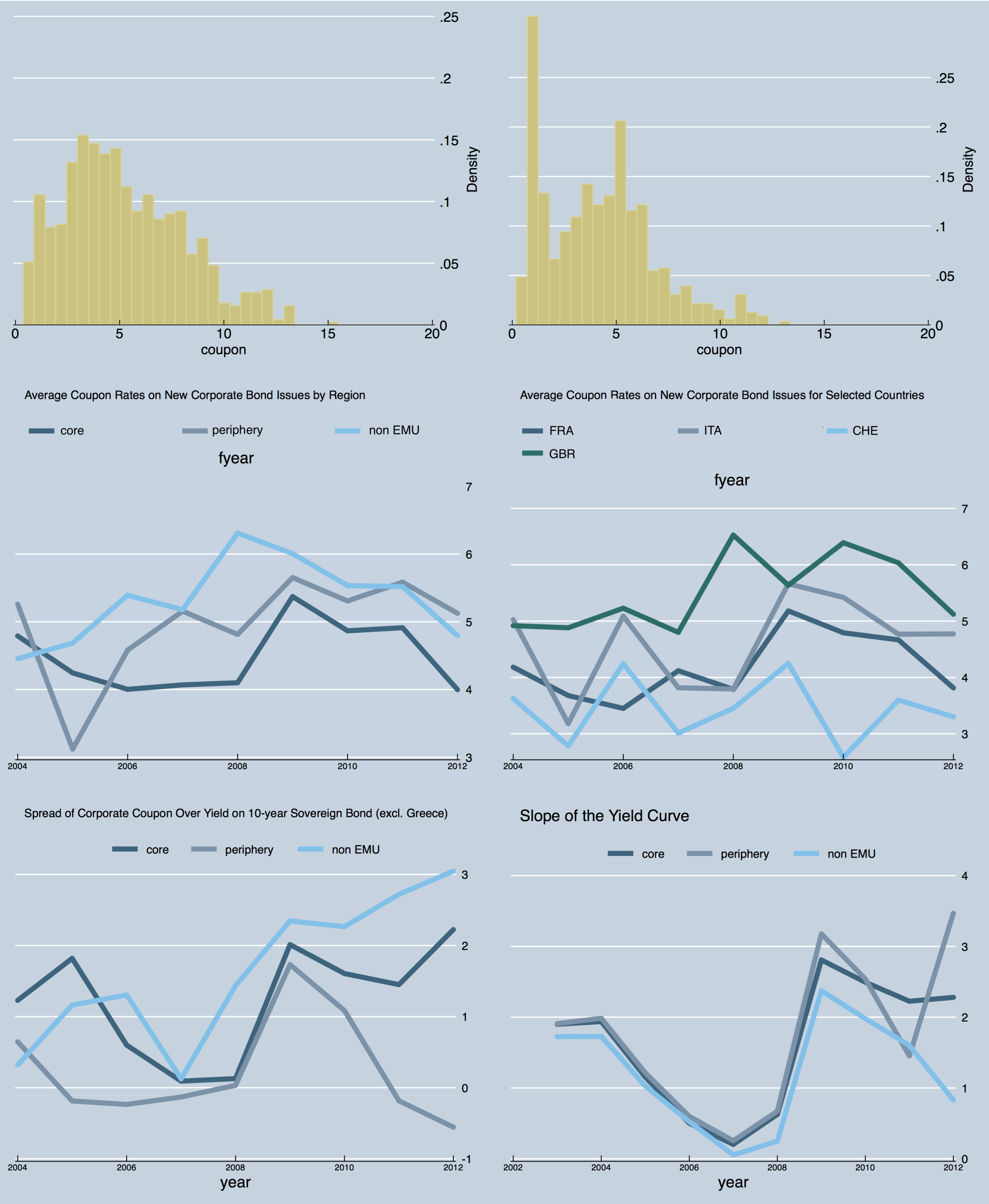


FIGURE 5.9: Maturity of corporate bond issues by country over time cont'd



Top left: Histogram of coupon rates for 5-year bonds before the 2008; Top right: Histogram of coupon rates for 5-year bonds after 2008; Center left: Average coupon rates of corporate bonds by region over time; Center right: Average coupon rates of corporates bonds in selected countries over time; Bottom left: Spread of corporate coupons over ten-year sovereign yields by region over time: Bottom right: Slope of the yield curve by region over time

FIGURE 5.10: Coupon rates

5.B Robustness checks for the number of bond issues

TABLE 5.14: Robustness to country exclusion

	AUT	BEL	CHE	DEU	DNK	ESP	FIN	FRA	GBR
Const.	0.265***	0.269***	0.268***	0.313***	0.301***	0.264***	0.299***	0.311***	0.306***
	(5.54)	(5.63)	(10.50)	(8.82)	(9.10)	(5.45)	(9.18)	(8.86)	(7.41)
EMU	0.047***	0.047***	0.050***	0.051***	0.044***	0.049***	0.048***	0.048***	0.088***
	(4.79)	(4.83)	(5.21)	(4.27)	(4.54)	(4.78)	(4.75)	(4.54)	(4.85)
PER	-0.067***	-0.067***	-0.068***	-0.070***	-0.069***	-0.065***	-0.067***	-0.064***	-0.075***
	(-4.40)	(-4.39)	(-4.47)	(-4.27)	(-4.62)	(-4.17)	(-4.36)	(-3.86)	(-5.25)
Obs	4216	4185	4097	3704	4166	4174	4174	3733	3036
R2	0.1669	0.1656	0.1599	0.1691	0.1690	0.1712	0.1653	0.1538	0.1976

	GRC	IRL	ITA	LUX	NLD	NOR	PRT	SWE
Const.	0.264***	0.301***	0.257***	0.267***	0.293***	0.291***	0.265***	0.262***
	(5.36)	(9.17)	(5.23)	(5.52)	(9.24)	(7.43)	(5.45)	(4.91)
EMU	0.049***	0.049***	0.050***	0.049***	0.055***	0.048***	0.049***	0.043***
	(4.74)	(4.79)	(5.15)	(4.83)	(5.69)	(4.77)	(4.80)	(3.91)
PER	-0.063***	-0.068***	-0.085***	-0.069***	-0.075***	-0.067***	-0.066***	-0.069***
	(-3.33)	(-4.26)	(-9.81)	(-4.56)	(-5.47)	(-4.51)	(-4.35)	(-4.64)
Obs	4086	4229	4063	4257	4167	4097	4242	3902
R2	0.1687	0.1681	0.1646	0.1671	0.1702	0.1641	0.1669	0.1688

Standard errors in parentheses are clustered on the country-level. * p<0.10, ** p<0.05, *** p<0.01. The estimations are based on the 'assets' specification as used in column (2) of table 5.4. All firms located in one country are excluded at a time; column 'AUT', for example, excludes all Austrian firms. The coefficient for *constant* measures the general impact of the crisis on the frequency of firms' bond issuances, while the coefficients on *EMU* and *PER* show the impact for core EMU member countries and GIIPS, respectively. The standard estimate is a linear probability model. Estimations control for the firm's average asset size during the 2009-2012 period and the home country's EU membership.

TABLE 5.15: Robustness to sector exclusion

	Energy	Material	Industrial	Cons. Disc.	Consumer Staples	Health Care	IT	Telecomm.	Utilities
Const.	0.245***	0.259***	0.297***	0.313***	0.263***	0.298***	0.274***	0.220***	0.212***
	(4.51)	(5.15)	(12.66)	(8.33)	(5.13)	(10.02)	(5.90)	(14.62)	(12.83)
EMU	0.050***	0.045***	0.048***	0.050***	0.045***	0.050***	0.054***	0.048***	0.049***
	(4.85)	(3.85)	(4.43)	(5.26)	(4.09)	(4.82)	(4.92)	(4.32)	(4.85)
PER	-0.071***	-0.061***	-0.061***	-0.075***	-0.070***	-0.070***	-0.074***	-0.066***	-0.071***
	(-5.12)	(-4.02)	(-3.59)	(-4.93)	(-4.18)	(-4.41)	(-4.31)	(-4.57)	(-4.92)
Obs	4012	3852	3268	3400	3983	3891	3495	4214	4149
R2	0.1669	0.1656	0.1662	0.1773	0.1688	0.1706	0.1748	0.1648	0.1514

Standard errors in parentheses are clustered on the country-level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$. The estimations are based on the 'assets' specification as used in column (2) of table 5.4. All firms attributed to one sector are excluded at a time; column 'Energy', for example, excludes all firms of the energy sector. The coefficient for *const.* measures the general impact of the crisis on the frequency of firms' bond issuances, while the coefficients on *EMU* and *PER* show the impact for core EMU member countries and GIIPS, respectively. The standard estimate is a linear probability model. Estimations control for the firm's average asset size during the 2009-2012 period and the home country's EU membership.

5.C Robustness checks for the maturity of bond issues

TABLE 5.16: Robustness to country exclusion

	AUT	BEL	CHE	DEU	ESP	FIN	FRA	GBR	GRC
Constant	2.425	2.083	2.126	1.982	-3.379**	2.005	-2.961	0.498	2.103
	(1.18)	(1.19)	(0.78)	(1.12)	(-2.57)	(1.14)	(-1.28)	(0.52)	(1.21)
(mean) emu	2.025**	1.964**	2.323***	2.268***	1.922**	2.200***	1.172	1.671*	1.904**
	(2.82)	(2.69)	(4.06)	(3.20)	(2.75)	(3.25)	(1.67)	(1.92)	(2.70)
emuper	-5.450**	-5.516**	-5.447**	-5.879**	-6.746***	-5.532**	-4.166**	-5.344**	-5.351**
	(-2.45)	(-2.43)	(-2.38)	(-2.64)	(-4.30)	(-2.45)	(-2.32)	(-2.30)	(-2.25)
Obs	162	165	150	151	164	161	138	147	167
R2	0.1788	0.1790	0.1851	0.2025	0.1962	0.1869	0.2077	0.1616	0.1778

	ITA	LUX	NLD	NOR	PRT	SWE
Constant	-3.258**	-3.275**	-3.294**	1.727	2.104	-4.548***
	(-2.52)	(-2.58)	(-2.55)	(0.75)	(1.21)	(-4.96)
(mean) emu	1.761**	1.784**	1.808**	1.698*	1.903**	1.881**
	(2.60)	(2.46)	(2.34)	(2.11)	(2.69)	(2.41)
emuper	-0.922	-5.211**	-5.234**	-5.362**	-5.757**	-5.568**
	(-0.78)	(-2.35)	(-2.26)	(-2.30)	(-2.78)	(-2.45)
Obs	157	166	159	144	167	154
R2	0.1428	0.1857	0.1706	0.1833	0.1892	0.1926

Standard errors in parentheses are clustered on the country-level. * p<0.10, ** p<0.05, *** p<0.01. The estimations are based on the 'baseline' specification as used in column (1) of table 5.6. All firms located in one country are excluded at a time; column 'AUT', for example, excludes all Austrian firms. The coefficient for *constant* measures the general impact of the crisis on the maturity of firms' bond issuances, while the coefficients on *EMU* and *PER* show the impact for core EMU member countries and GIIPS, respectively. The baseline specification does not control for firm specific or macroeconomic variables. The standard estimate is a linear probability model.

TABLE 5.17: Robustness to sector exclusion

	Energy	Material	Industrial	Cons. Disc.	Consumer Staples	Health Care	IT	Telecomm.	Utilities
Const.	2.100	-3.621**	-3.813**	-2.820**	2.186	-0.082	-0.084	-3.430**	-3.188**
	(1.21)	(-2.59)	(-2.69)	(-2.52)	(1.25)	(-0.10)	(-0.11)	(-2.55)	(-2.43)
EMU	1.914**	2.245***	2.501**	1.177*	1.657**	2.013**	2.016**	1.991**	1.667**
	(2.91)	(3.32)	(2.52)	(1.84)	(2.15)	(2.62)	(2.82)	(2.70)	(2.39)
PER	-5.693**	-5.515**	-6.336**	-2.220	-5.226**	-5.401**	-5.402**	-5.840**	-6.863**
	(-2.28)	(-2.46)	(-2.68)	(-1.57)	(-2.32)	(-2.42)	(-2.44)	(-2.85)	(-2.19)
Obs	148	147	129	147	152	162	164	154	141
R2	0.1872	0.1877	0.1856	0.1329	0.1683	0.1706	0.1818	0.1841	0.2133

Standard errors in parentheses are clustered on the country-level. * $p<0.10$, ** $p<0.05$, *** $p<0.01$. The estimations are based on the 'baseline' specification as used in column (1) of table 5.6. All firms attributed to one sector are excluded at a time; column 'Energy', for example, excludes all firms of the energy sector. The coefficient for *constant* measures the general impact of the crisis on the maturity of firms' bond issuances, while the coefficients on *EMU* and *PER* show the impact for core EMU member countries and GIIPS, respectively. The baseline specification does not control for firm specific or macroeconomic variables. The standard estimate is a linear probability model.

Curriculum Vitae

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EDUCATION

2011 - 2015	**University of St. Gallen (HSG),** *Switzerland* PhD in Economics and Finance (Track: Economics) Th. Committee: C. Keuschnigg/R. Föllmi (HSG), P. Pfleiderer (Stanford)
2013 - 2014	**Stanford University,** Stanford Graduate School of Business, *United States* Visiting PhD Student for one year | Advisors: P. Pfleiderer & A. Admati Full scholarship from the Swiss National Science Foundation
2006 - 2011	**Leopold-Franzens-Universität Innsbruck,** *Austria* Mag.rer.soc.oec in Economics Mag.rer.soc.oec in International Business Studies
2009 - 2009	**Queensland University of Technology (QUT),** *Australia* Exchange Student for one year, full scholarship
2001 - 2006	**Bundeshandelsakademie Schwaz,** *Austria* Matura/High School degree

PROFESSIONAL EXPERIENCE

2011 - today	**University of St. Gallen (HSG),** *Switzerland,* Research & Teaching Ass.
2010	**Rothschild,** *Germany,* Investment Banking – Mergers & Acquisitions
2008	**General Electric,** *Austria,* Corporate Finance and Controlling
2008 - 2009	**Leopold-Franzens-Universität Innsbruck,** *Austria,* Teaching Assistant
2007	**General Electric,** *Austria,* Corporate Finance and Accounting
2006	**Binder Holz,** *Austria,* Production Process
2005	**Erste Bank/Sparkasse Schwaz AG,** *Austria,* Global Fund Selection
2005	**LKW Walter,** *Austria,* Logistics
2004 & 2003	**Versicherungsmaklerbüro Wetscher,** *Austria,* Insurance Services
2004	**Darbo AG,** *Austria,* Imports/Exports

TEACHING

2011 - 2016	Introduction to Macroeconomics (assessment level)
2011 - 2013	Introduction to Microeconomics (assessment)
2012 - 2015	Microeconomics II (bachelor)
2013	Advanced Microeconomics (master)
2012 - 2015	Entrepren. Finance, Venture Capital and Econ. Performance (master)
2015	Public Economics (master)
2008 - 2009	Macroeconomics (bachelor), Leopold-Franzens-Universität Innsbruck

FURTHER INFORMATION: A full curriculum vitae is available upon request